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The Open Court

A MONTHLY MAGAZINE

Devoted to the Science of Religion, the Religion of Science, and the Extension of the Religious Parliament Idea

Founded by Edward C. Hegeler

ROGER BACON.
1214-1914.

The Open Court Publishing Company

CHICAGO AND LONDON

Per copy, 10 cents (sixpence). Yearly, $1.00 (in the U.P.U., 5s. 6d.).

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ISIS REVUE CONSACREE A L'HISTOIRE ET A L'ORGANISATION DE LA SCIENCE, PUBLIEE PAR GEORGE SARTON

En résumé *Isis* est à la fois la revue philosophique des savants et la revue scientifique des philosophes; la revue historique des savants et la revue scientifique des historiens; la revue sociologique des savants et la revue scientifique des sociologues. Conçoit-on encore un philosophe, un historien, un sociologue ignorant tout de l'évolution et de l'organisation scientifiques de l'humanité? Tout philosophe préoccupé de science, tout savant préoccupé d'idées générales, soucieux de regarder au-dessus des cloisons de sa spécialité *doit donc s'abonner à ISIS.* — Le tome I (1913/14) a paru: 826 p. gr. 8°, l'index seul occupant 58 colonnes. (Prix: 30 frs.) Deux grands portraits hors texte. Les exemplaires restants seront réservés de préférence aux souscripteurs du tome II. Prix du tome II: 15 frs. *Demandez le programme et des extraits d'Isis à l'administration à*

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ROGER BACON.

BY THE EDITOR.

SEVEN hundred years ago, in 1214, Roger Bacon, easily the greatest man of the middle ages, was born. He was not a powerful king like Charlemagne (742 or 747-814), not a great pope like Gregory VII (1020-1085), not a great instigator of crusades like Bernard of Clairvaux (1091-1153), not a master in giving shape to church dogma like Anselm of Canterbury (1033-1109), not a great preacher like Eckhart (1260-1328), not a great devotional writer like Thomas à Kempis (1380-1471), not the founder of a religious order like St. Francis of Assisi (1182-1226),—he was far greater than all of them, he was a man of science. Indeed it is not impossible that he was the only true scientist that lived in the middle ages, and so he was in advance of his time by more than half a millennium; in his enthusiasm for science he foresaw the automobile and the flying machine in his predictions of what science could accomplish, and as a result he was treated as might have been expected. He was accused of black magic and was kept in prison for about twelve years.

In the days of Roger Bacon there was no doubt that he deserved no better fate. He was a mathematician and one of his hobbies was optics. Once when he was lecturing in the University of Paris—then the center of all intellectual life—he exhibited the spectrum to his audience, making God's glorious rainbow colors appear on the wall! The effect was remarkable. His hearers fled from the room in great agitation lest they would share in the curse of witnessing deeds of Satanic exorcism.

Roger Bacon's thoughts and methods would have been lost and he would have become a mere myth of a sorcerer, had not one of the few admirers of his accomplishments who became pope, ascending the papal throne in 1265 under the name of Clement IV, requested him to write down his theories and send them to Rome, even if all his superiors were to forbid him. This happened in 1267. Unfortunately Pope Clement IV died in 1267, and Roger Bacon lost his powerful protector.

Philosophy in the middle ages was characterized mainly by the struggle between realism and nominalism. Realism in those days was very different from the realism of modern times. Medieval realism believed in the reality of ideas, considering them as entities or *res*; and thus it was practically an extreme idealism. Nominalism rebelled against the authority of the firmly established realism, and was represented by Roscellinus, who claimed that ideas were mere names or *nomina*, and these names were nothing but words, *flatus vocis*. The greatest representatives of medieval realism were Johannes Scotus Erigena (c. 800-891) and Anselm of Canterbury. All the great men of scholasticism took part in this struggle between nominalism and realism. Prominent among them were Albertus Magnus (1193-1280), and above all Thomas Aquinas (1225-1274). The latter represents a kind of compromise with pagan philosophy, summed up in Aristotle, and Christian dogma. Realism remained victorious, the last prominent representative of nominalism being William of Occam (1270-1347). In the meantime a preparation for more scientific views came from the Ara-

ROGER BACON.

From Crabb's *Universal Dictionary of Names.*

From *Popular Science Monthly,* LI, p. 147.

bians, the greatest among them being Averroes (1126-1198), whose philosophy was transmitted to the Christian nations by the great Jew Moses Maimonides (1135-1204).

In the thirteenth century appeared Roger Bacon, a Franciscan monk who stands in glaring contrast to the spirit of the middle ages. He was imbued with a new spirit insisting upon the only true method of research, which is by experiment. Influenced by the Arabians and their Occidental followers, Roger Bacon understood the paramount significance of mathematics and applied it in the laboratory. But for all that we must not think that he possessed the results and applications of this basic principle of science. After all he remained in almost all important details the child of his age. He did not see the difficulties of Christian dogma, nor of the superstitions of the time. He still dabbled in astrology and wasted much thought and labor on topics of Biblical archeology. In fact these problems were favorite objects of investigation with him, for he was a faithful son of the church withal. He had bright visions of the future; but they were still visions, mere fanciful dreams, and the reality in which he lived remained the monkish conception of the world that surrounded him in life. Let us not for that reason think the less of him. When we consider what high value Isaac Newton placed upon his own explanations of the vision of John the Divine and the significance of the prophecies preserved in Revelations, we shall not judge harshly of Roger Bacon but shall perhaps appreciate him the more because we learn to understand better how difficult it was to break away from the traditions of medievalism.

In this number[1] we celebrate the septencentennial anniversary of Roger Bacon's birth. Honor to his memory!

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[1] The next number also will contain an article on "Philology and the Occult in Roger Bacon" from the pen of Prof. John S. P. Tatlock of the university of Michigan.

BIOGRAPHY OF ROGER BACON.[1]

EXTANT FRAGMENTS OF HIS WORKS.

SOME part of this biography will make the rest more intelligible if made a preliminary explanation. Before the appearance of Wood's *History of Oxford* (1674), no one had added anything to the summaries of Leland, Bale, and Pits, which are little more than ill-understood lists of works. The name of Bacon was known far and wide as a magician; and the better informed could only judge from such fragments as had been published, and from the traditional reputation of what remained in manuscript, that he was a philosopher of the highest genius. These printed fragments are as follows, so far as we can collect them, being all that was published down to the appearance of Dr. Jebb's edition of the *Opus majus* which closes the list:

1. *De mirabili potestate artis et naturæ et nullitate magiæ,* Paris, 1542, 4to; Basil., 1593, 8vo; in English,[1] Lond., 1597, 4to; Hamb. 1608 and 1618, 8vo; in French, Par., 1612, 8vo; also in French, by Girard, Par., 1557 and 1629; in Vol. V of Zetzner's *Theatrum chemicum,* Argent., 1622, 8vo, and 1659 (?); in English, by T. M., London, 1659, 12mo.

2. *Perspectiva, Specula mathematica,* and *De speculis ustoriis,* Francof., 1614, 4to, whether as one book or three we do not know; the *Perspectiva* was reprinted in 1671, also at Frankfort.

3. *De retardatione senectutis,* Oxon., 1590, 8vo.; translated, *The Cure of Old Age,* by R. Browne, M. D., Lond., 1683, 12mo.

4. *De secretis operibus artis et naturæ,* Hamb., 1618, 8vo, edited by John Dee.

5. The *Thesaurus chemicus,* Frankfort, 1603 and 1620, 8v (?) contains the *Specula mathematica,* the *Speculum alchymiæ,* and some other tracts, which Tanner puts down altogether as *Scripta sanioris medecinæ in arte chemiæ.*

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[1] Reprinted from an anonymous article in *Old England's Worthies,* London, 1853.

6. *Speculum alchymiæ,* Norimb., 1581, 4to; Basil., 1561, 4to; Ursellis, 1602, 8vo; in English, in *Collectanea chymica,* Lond., 1684, 8vo; also[1] in English, Lond., 1597, 4to.

7. *Practica Magistri Rogerii,* Venet., 1513 and 1519.

8. *Epistolas notis illustratas* (we take the title from Tanner), Hamb., 1618, 8vo.

9. *Fratris Rogeri Bacon, Ordinis Minorum, Opus majus, ad Clementem IV. Pontif. Rom.,* Londini, 1733, fol. By Dr. Jebb.

HIS AGE AND CONTEMPORARIES.

The little that is known of the greatest of English philosophers before the time of his celebrated namesake, shows how long the effects of contemporary malice might last, before the invention of printing had made an appeal to posterity easy. His writings, destroyed or overlooked, only existed in manuscript or mutilated printed versions, till nearly the middle of the eighteenth century. In the meantime tradition framed his character on the vulgar notions entertained in his day of the results of experimental science; and the learned monk, searching for the philosopher's stone in his laboratory, aided only by infernal spirits, was substituted for the sagacious advocate of reform in education, reading, and reasoning; and—what was equally rare—the real inquirer into the phenomena of nature.

Roger Bacon died in 1292, in about the seventy-eighth year of his age, which places his birth near the year 1214; roughly speaking, he lived from the time of the Interdict in the reign of John, to the beginning of the interference with Scotland in that of Edward I. His age is that of Cardinal Cusa, Thomas à Kempis, Matthew Paris, Albertus Magnus, Raymond Lully, Sacrobosco etc., to whom we add, as they are sometimes confounded with him, and not for their own note, two theologians, Robert Bacon and John Bacon (died about 1346). The former was a priest of the thirteenth century, whom it would be hardly necessary to notice but for the fact that some of our historians have made him the brother of Roger Bacon, and the two have been often confounded. He is stated to have studied successively at Oxford and Paris; and in 1233, when his friend and teacher, Edmund Rich, was removed from the treasurership of Salisbury Cathedral to the archbishopric of Canterbury, Robert Bacon was his successor. The archbishop was canonized by the title of St. Edmund; and Bacon wrote his life. Matthew Paris states that in 1233 Robert Bacon preached before Henry III at Oxford, and spoke openly against the favorite, Peter des Roches (or De Rupibus), of Poitou, Bishop of Winchester, who had given great offence by the introduction and promotion of many of his countrymen. Serious disturbance was apprehended, and the king appeared to waver; on which, says the historian, a witty court chaplain, called *Roger* Bacon, asked his Majesty what was most dangerous to seamen. The king answered that seamen best knew, on which the chaplain rejoined, "Petræ et Rupes; ac diceretur, Petrus de Rupibus." This story is the likely origin of the connection between Robert and Roger, and also of the account which states that Roger Bacon, the subject of this article, preached before the king on the same occasion. Robert Bacon joined the order of preaching friars in his old age, and died in 1248, whence the story (certainly false) that Roger died in that year. (*Biogr. Britann.*; Tanner, *Biblioth. Britan. Hibern.*; Wood, *Hist. et Ant. Oxon.*)

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[1] These two are in the same book.

EDUCATION.

Roger Bacon was born near Ilchester, in Somersetshire, of a respectable family. He was educated at Oxford, and, according to the usual custom of his day, proceeded to Paris, which was then the first university in the world. The course of study in vogue, however unfavorable to independence of thought, did not give so great a preponderance to the works of Aristotle as was afterwards the case. The theology of the day had set strongly against philosophy of every species. In 1209 a council at Paris condemned and burnt, if not the works of Aristotle, at least the mutilated and interpolated translations from the Arabic which then existed. But when, towards the middle of the century, Latin versions from the Greek began to appear, and the philosophy contained in them to be warmly advocated by the new orders of Franciscans and Dominicans, and particularly by Albertus Magnus (died 1282), the reputation of Aristotle advanced so rapidly, that he had gained the exclusive title of "the philosopher" by the time Roger Bacon wrote his *Opus majus*. But Bacon in no sense became an Aristotelian, except in that which comprehends all who are acquainted with the opinions and methods of the Greek philosopher. Better versed in the original than most of his contemporaries, he freely criticises all he meets with (especially the merit of the translations, which he says he would burn if he could), and is himself an early and sufficient proof that the absurdities of his successors ought not to be called "Aristotelian," any more than Aristotle himself "the philosopher." Bacon could read Aristotle without danger of falling into idolatry: his antagonists could have erected a system of verbal disputes upon the *Principia* of Newton, if they had possessed it.

After his return to Oxford, with a doctor's degree granted at Paris, which was immediately also confirmed by the former university, he took the vows of a Franciscan in a convent possessed by that order at Oxford, on the persuasion, it is said, of Robert Greathead or Grostête, Bishop of Lincoln, of whom we shall presently speak. It has been conjectured that he had already done so before his return to Oxford, but this appears to have arisen from his having been known to have resided in a Franciscan convent while at Paris. From the time of his return, which is stated to have been A. D. 1240, he applied himself closely to the study of languages, as well as to experimental philosophy. In spite of the vow of poverty, he does not appear to have wanted means, for he says himself that in twenty years he spent 2000 livres (French) in books and instruments; a very large sum in those days.

The vow of the Franciscans was poverty, manual labor, and study; but the first two were soon abandoned. On this subject we notice a writing of Bacon, of which (except in Dr. Jebb's list) we can find only one casual notice (in Vossius, *De his. lat.* article "Bacon"). It is said that he answered a work of St. Bonaventure, general of his order, which treated of the above-mentioned vow; but which side either party adopted is not stated.

ENEMIES AND FRIENDS.

The enmity of his brethren soon began to show itself: the lectures which he gave in the university were prohibited, as well as the transmission of any of his writings beyond the walls of his convent. The charge made against him was that of magic, which was then frequently brought against those who studied the sciences, and particularly chemistry. The ignorance of the clergy of that time as to mathematics or physics was afterwards described by Anthony-à-Wood, who says that they knew no property of the circle except that of keeping out the devil, and thought the points of a triangle would wound religion. Brought up to consider philosophy as nearly allied to, if not identical with, heresy itself, many of them might perhaps be honest believers in its magical power: but we can hardly doubt that there were a few more acute minds, who saw that Roger Bacon was in reality endeavoring to evoke a spirit whose influence would upset the power they had acquired over the thoughts of men, and allow them to read and reflect, without fear of excommunication, or the necessity of inquiring what council had authorized the book. Not that we mean to charge those minds in every instance with desiring such power for their own private ends: there has always been honest belief in the wickedness of knowledge, and it is not extinct in our own day. The following detached passages of the *Opus majus* no doubt contain opinions which its author was in the habit of expressing:

"Most students have no worthy exercise for their heads, and therefore languish and stupefy upon bad translations, which lose them both time and money. Appearances alone rule them, and they care not what they know, but what they are thought to know by a senseless multitude....There are four principal stumbling-blocks in the way of arriving at knowledge—authority, habit, appearances as they present themselves to the vulgar eye, and concealment of ignorance combined with ostentation of knowledge.... Even if the first three could be got over by some great effort of reason, the fourth remains ready....Men presume to teach before they have learnt, and fall into so many errors, that the idle think themselves happy in comparison; and hence both in science and in common life we see a thousand falsehoods for one truth....And this being the case, we must not stick to what we hear or read, but must examine most strictly the opinions of our ancestors, that we may add what is lacking, and correct what is erroneous, but with all modesty and allowance....We must, with all our strength, prefer reason to custom, and the opinions of the wise and good to the perceptions of the vulgar: and we must not use the triple argument; that is to say, this has been laid down, this has been usual, this has been common, therefore it is to be held by. For the very opposite conclusion does much better follow from the premises. And though the whole world be possessed by these causes of error, let us freely hear opinions contrary to established usage."

As might be supposed, Roger Bacon cultivated the acquaintance of men who held sentiments similar to the above, which could not please his brethren. Among them we have mentioned Grostête, Bishop of Lincoln, who usually resided at Oxford. This prelate, who was a good mathematician, and a resolute opponent of undue interference on the part of the see of Rome (*terrificus papà redargutor,* says Camden), had opposed Innocent IV, who attempted to appoint his nephew, a boy, to a prebend at Lincoln. On being excommunicated, Grostête appealed from the tribunal of Rome to that of Christ; and so prevalent was the opinion of his antipathy to the pope, that a story is gravely told by Knyghton (cited by Blount, *Censura*, etc.), that the Bishop of Lincoln, after his death, appeared to Innocent in a dream, and exclaiming, "*Surge miser, veni in judicium*!" actually stabbed his Holiness, who was found dead next morning. It is needless to say that Innocent IV died a natural death, and useless to speculate upon the means by which such a circumstance as the preceding, if true, could come to be known. But perhaps the memory of Grostête may have been one reason of the willingness with which succeeding popes continued Bacon's imprisonment, to which we shall soon come; for though they might hold his spirit guiltless of the death of Innocent, they long remembered what he had done in the flesh; and when Edward I and the University of Oxford, long after, applied to Clement V for the canonization of Grostête, they received for answer that the pope would rather his bones were thrown out of consecrated ground.

In the meantime a pope was elected to whom we owe the production of the *Opus majus*. This was Clement IV (elected 1265), who had previously, when cardinal-bishop of Sabina, been legate in England. Here he had heard of Bacon's discoveries, and earnestly desired to see his writings; but, as before stated, the prohibition of the Franciscans prevented his wish being complied with. After his election as head of the church, Bacon, conceiving that there would be no danger nor impropriety in disobeying his immediate superiors at the command of the pope, wrote to him, stating that he was now ready to send him whatever he wished for. The answer was a repetition of the former request; and Bacon accordingly drew up the *Opus majus,* of which it may be presumed he had the materials ready. It appears that he had mentioned the circumstances in which he stood; for Clement's answer requires him to send the work with haste, any command of his superiors or constitution of his order notwithstanding, and also to point out, with all secrecy, how the danger mentioned by him might be avoided. The book was sent in the year 1267, by the hands of John of London, a pupil of whom he speaks highly, and who has usually obtained some notice from the very great praise which Bacon in one place appears to give him, when he says that he only knows two good mathematicians, one of whom he calls John of London. But from some other circumstances Dr. Jebb concludes, with great probability, that this John was not the pupil above mentioned, but John Peccam, a London Franciscan, afterwards Archbishop of Canterbury, who was well known as a mathematician, and whose treatise on optics, *Perspectivæ communis* *libri tres,* was printed at least six times between 1542 and 1627, at Nuremberg, Venice, Paris, and Cologne.

Before the *Opus majus,* Bacon, according to his own account, had written nothing except a few slight treatises, "*capitula quædam.*" Before he took the vows he wrote nothing whatever; and afterwards, as he says to Clement, he would have composed many books for his brother and his friends, but when he despaired of ever being able to communicate them, he neglected to write.

With the *Opus majus* he sent also two other works, the *Opus minus* and the *Opus tertium,* the second a sort of abstract of the first, and the third a supplement to it. These exist in manuscript in the Cottonian Library, but have not been printed. It appears that, after the death of Clement, which took place in November, 1268 (not 1271, as stated by some; the latter date is that of the election of Clement's successor, the see having been vacant two years and three-quarters), he revised and augmented the second of these works. What reception Clement gave them is not known: some say he was highly gratified and provided for the bearer; others, that he at least permitted an accusation of heresy against the writer. Both stories are unlikely: for Clement could hardly have received the work before he was seized with his last illness.

Till the year 1278 Bacon was allowed to remain free from open persecution; but in that year Jerome of Ascoli, general of the Franciscan order, afterwards pope, under the title of Nicholas IV, being appointed legate to the court of France, this was thought a proper opportunity to commence proceedings. Bacon, then sixty-four years old, was accordingly summoned to Paris (Dr. Jebb implies that he had already removed his residence there, to another convent of his order), where a council of Franciscans, with Jerome at their head, condemned his writings, and committed him to close confinement. According to Bale, or Balæus (cited by Dr. Jebb), the charge of innovation was the pretext, but of what kind was not specified; according to others, the writings of Bacon upon astrology were the particular ground of accusation. We cannot learn that any offer of pardon was made to the accused upon his recantation of the obnoxious opinions, as usual in such cases; which, if we may judge from the *Opus majus,* Bacon would have conceived himself bound to accept, at least if he recognized the legality of the tribunal. A confirmation of the proceeding was immediately obtained from the court of Rome. During ten years, every effort made by him to procure his enlargement was without success. The two succeeding pontiffs had short and busy reigns; but on the accession of Jerome

(Nicholas IV), Bacon once more tried to attract notice. He sent to that pope, it is said, a treatise on the method of retarding the infirmities of old age, the only consequence of which was increased rigor and closer confinement. But that which was not to be obtained from the justice of the pope, was conceded to private interest, and Bacon was at last restored to liberty by the intercession of some powerful nobles, but who they were is not mentioned. Some say he died in prison; but the best authorities unite in stating that he returned to Oxford, where he wrote a compendium of theology, and died some months, or perhaps a year and a half, after Nicholas IV (who died April, 1292). We have adopted 1292 from Anthony-à-Wood, as the most probable year of his death, though foreign works frequently state that he died in 1284. He was buried in the church of the Franciscans at Oxford. The manuscripts which he left behind him were immediately put under lock and key by the magic-fearing survivors of his order, until, not so lucky as those of another wizard, Michael Scott, they are said to have been eaten by insects.

HIS WORKS.

Of the asserted works of Bacon there is a very large catalogue, cited mostly from Bale and Pits, in the preface to Dr. Jebb's edition of the *Opus majus.* They amount to five on grammar, six on pure mathematics, seventeen on mechanics and general physics, ten on optics, six on geography, seven on astronomy, one on chronology, nine on chemistry and alchemy, five on magic, eight on logic and metaphysics, nine on medicine, six on theology, twelve miscellaneous; a hundred and one in all. But it is most likely that the greater part of these were extracts from the *Opus majus,* etc., with separate titles, that some are not genuine, and that others are more properly attributable to the two other Bacons already mentioned. The principal manuscripts of the *Opus majus* are, one in Trinity College Library, Dublin, discovered by Dr. Jebb, which forms the text of his edition, two in the Cottonian Library, one in the Harleian, one in the library of Corpus Christi College, Cambridge, one in that of Magdalen College, two in the King's Library, all containing various parts of the work. These are independent of the *Opus minus* and *Opus tertium* in the Cottonian Library, already mentioned, of some in Lambeth Palace, in the Bodleian Library at Oxford, and a host of others at home and abroad which we cannot specify. The Dublin manuscript is the only entire one with which Dr. Jebb was acquainted. It is a folio of 249 leaves, beautifully written on thick paper, with a good margin, and in double columns. It is not dated, but from the character of the writing it is judged to be of the reign of Henry VIII, or perhaps the early part of that of Elizabeth. The geometrical figures are neatly drawn in the margin. Pope Clement's letters are in the Vatican Library.

It only remains for us to take a general view of the character of Roger Bacon's writings, and of the contents of the *Opus majus.* It is surprising how little is known of this work, the only one in print to which we can appeal, if we would show that philosophy was successfully cultivated in an English university during the thirteenth century. It is of course in Latin, but in Latin of so simple a character, that we know of none in the middle ages more easy to read; and it forms a brilliant exception to the stiff and barbarous style of that and succeeding times. We think we see the thoughts of the author untranslated, though the idiom is often that of an Anglo-Norman; by which we mean that we frequently find Latin words used in their modern English sense, as, for instance, *intendere* for *in animo habere,* meaning the same as our word "to intend"; *præsumere* for *sibi arrogare* in the sense of "to presume." We should perhaps rather say that the English words receive their meaning from the corrupted Latin, and not *vice versa,* in which case the work of Roger Bacon may become useful in tracing the change, and the more so on account of the great simplicity of the style.

THE CHARGE OF HERESY.

The charge of heresy appears to be by no means so well founded as a Protestant would wish. Throughout the whole of his writings Bacon is a strict Roman Catholic, that is, he expressly submits matters of opinion to the authority of the church, saying (Cott. MSS. cited by Jebb) that if the respect due to the vicar of the Saviour, *vicarius Salvatoris,* alone, and the benefit of the world, could be consulted in any other way than by the progress of philosophy, he would not, under such impediments as lay in his way, proceed with his undertaking for the whole church of God, however much it might entreat or insist. His zeal for Christianity, in its Latin or Western form, breaks out in every page; and all science is considered with direct reference to theology, and not otherwise. But at the same time, to the credit of his principles, considering the book-burning, heretic-hunting age in which he lived, there is not a word of any other force except that of persuasion. He takes care to have both authority and reason for every proposition that he advances: perhaps, indeed, he might have experienced forbearance at the hand of those who were his persecutors, had he not so clearly made out prophets, apostles, and fathers to have been partakers of his opinions. "But let not your Serenity imagine," he says, "that I intend to excite the *clemency* of you Holiness, in order that the papal majesty should employ force against weak authors and the multitude, or that my unworthy self should raise any stumbling-block to study." Indeed the whole scope of the first part of the work is to prove, from authority and from reason, that philosophy and Christianity cannot disagree; a sentiment altogether of his own revival, in an age in which all philosophers, and mathematicians in particular, were considered as at best of dubious orthodoxy.

The reasoning of Bacon is generally directly dependent upon his premises, which, though often wrong, seldom lead him to the prevailing extreme of absurdity. Even his astrology and alchemy, those two great blots upon his character, as they are usually called, are, when considered by the side of a later age, harmless modifications, irrational only because unproved, and neither impossible nor unworthy of the investigation of a philosopher, in the absence of preceding experiments. His astrology is *physical.* "With regard to human affairs, true mathematicians do not presume to make certain, but consider how the body is altered by the heavens, and the body being altered, the mind is excited to public and private acts, free will existing all the same." An age which is divided upon the question of the effect of the moon upon lunatics, and of which the philosophers have collected no facts decisive against many alleged effects of the same planet upon plants, can ask no more of a philosopher of the thirteenth century than that he should not be too positive. The fame of Leibnitz has not suffered from the *pre-established harmony* one-half as much as that of Bacon from his astrology and alchemy, which were believed in to a much greater extent by many of the learned of his time, and the united effect of which would seem to us sense and logic, compared with the metaphysical folly, all his own, of the eminent philosopher just cited.

This planetary influence appears to have been firmly believed in by Bacon, and in particular the effect of the constellations on the several parts of the human body. Perhaps he was rather prejudiced in favor of a doctrine which was condemned by the same men who thought mathematics and philosophy savored of heresy. And it must be remembered that the pretended science was almost universally allowed existence, even by those who considered its use unlawful; nor can we infer that the church disbelieved it, because that body discouraged it, any more than that it rejected infernal spirits, because it anathematized magic.

We must draw a wide distinction between the things which Bacon relates as upon credible authority, and the opinions which he professes himself to entertain from his own investigation. In almost every page we meet with something now considered extremely absurd, and with reason. But before the day of *printing* there was very little *publishing*: a book which was written in one country found its way but slowly into others, one copy at a time; and a man of learning seldom met those with whom he could discuss the probability of any narrative. The adoption of the principle that a story must be rejected because it is strange, would then have amounted to a disbelief of all that had been written on physics; a state of mind to which we cannot conceive any one of that age bringing himself. Nor can we rightly decide what opinion to form of Bacon as a philosopher, until we know how much he rejected, as well as how much he believed. These remarks apply particularly to his alchemy: he does not say he had made gold himself, but that others had asserted themselves to have made it; and his account of the drink by which men had lived hundreds of years is a relation taken from another. Voltaire, in his "Philosophical Dictionary," has overlooked this distinction, and has much to say in consequence. It was, however, no very strange matter that Bacon, who (if the *Speculum alchemiæ* be really his, of which, from the style, we doubt) believed with many others that sulphur and mercury were the first principles of all bodies, should endeavor to compound gold, or should give credit to the assertions of those who professed to have done so. But there is not in Bacon's alchemy any direction for the use of prayers, fasting, or planetary hours.

ALLEGED INVENTIONS.

The great points by which Bacon is known are his reputed knowledge of gunpowder and of the telescope. With regard to the former, it is not at all clear that what we call gunpowder is intended, though some detonating mixture, of which saltpeter is an ingredient, is spoken of as commonly known. The passage is as follows:

"Some things disturb the ear so much, that if they were made to happen suddenly by night, and with sufficient skill, no city or army could bear them. No noise of thunder could compare with them. Some things strike terror on the sight, so that the flashes of the clouds are beyond comparison less disturbing; works similar to which Gideon is thought to have performed in the camp of the Midianites. And an instance we take from a childish amusement, which exists in many parts of the world, to wit, that with an instrument as large as the human thumb, by the violence of the salt called saltpeter, so horrible a noise is made by the rupture of so slight a thing as a bit of parchment, that it is thought to exceed loud thunder, and the flash is stronger than the brightest lightning." —*Opus majus,* p. 474.

There are passages in the work *De secretis operibus,* etc. (cited by Hutton, *Dictionary,* article "Gunpowder"), which expressly mention sulphur, charcoal, and saltpeter as ingredients. But independently of the claim of the Chinese and Indians, there is an author, Marcus Græcus, whose work, *Liber ignium* (now existing only in Latin translations from the Greek), is cited by Dr. Jebb from a manuscript in the possession of Dr. Mead, and who appears to have been considered by both as older than Bacon. Dr. Hutton, into whose hands Dr. Mead's manuscripts passed, found this writer mentioned by an Arabic physician of the ninth century. Græcus gives the receipt for gunpowder, namely, one part of sulphur, two of willow-charcoal, and six of saltpeter. Two manuscript copies of Græcus were also found in the Royal Library of Paris. But it does not appear that Græcus was known for a long time after Bacon: even Tartaglia knew nothing of him; for he says, in his work on artillery, that the oldest writers known to him use equal parts of the three ingredients.

With regard to the telescope, it must be admitted that Bacon had *conceived* the instrument, though there is no proof that he carried his conception into practice, or *invented* it. His words are these: "We can so shape transparent substances, and so arrange them with respect to our sight and objects, that rays can be broken and bent as we please, so that objects may be seen far off or near, under whatever angle we please; and thus from an incredible distance we may read the smallest letters, and number the grains of dust and sand, on account of the greatness of the angle under which we see them; and we may manage so as hardly to see bodies, when near to us, on account of the smallness of the angle under which we cause them to be seen: for vision of this sort is not a consequence of distance, except as that affects the magnitude of the angle. And thus a boy may seem a giant, and a man a mountain, etc." The above contains a true description of a telescope; but if Bacon had constructed one, he would have found that there are impediments to the indefinite increase of the magnifying power; and still more that a boy does not appear a giant, but a boy at a smaller distance.

That the remarks of Bacon are derived from reflection and imagination only, is further apparent from his asserting that a small army could be made to appear very large, and that the sun and moon could be made to descend, to all appearance, down below, and stand over the head of the enemy. At the same time it is worth notice, that these ideas of Bacon did, in after times, produce either the telescope, or some modification of it, consisting in the magnifying of images produced by reflection, and that before the date either of Jansen or Galileo. Thomas Digges, son of Leonard Digges, in his *Stratiotikos,* London, 1590, page 359 (second edition, the first being 1579), thus speaks of what his father had done, in the presence, as he asserts, of numerous living eye-witnesses:

"And such was his Felicitie and happie successe, not only in these conclusions, but also in y^e Optikes and Catoptikes, that he was able by Perspectiue Glasses, duely scituate upon conuenient angles, in such sort to discouer every particularitie of the country round about, wheresoeuer the Sunne beames might pearse: as sithence Archimedes (Bakon of Oxford onely excepted) I have not read of any in action euer able by means natural to perform the like. Which partly grew by the aid he had by one old written book of the same Bakon's Experiments, that by strange aduenture, or rather Destinie, came to his hands, though chiefely by conioyning continuall laborious Practise with his Mathematicall Studies."

And the same Thomas Digges, in his *Pantometria,* London, 1571, Preface (republished in 1591), had previously given the same story, with more detail, omitting, however, all mention of Bacon. He says that his father—"sundrie times hath by proportionall Glasses duely situate in conuenient angles, not onely discouered things farre off, read letters, numbered peeces of money with the very coyne and superscription thereof, cast by some of his freends of purpose upon Downes in open Fields, but also seuen miles off declared what hath beene doone at that instant in priuate places. There are yet living diuerse (of these his dooings) *oculati testes.*"

The question has been agitated whether the invention of spectacles is due to Bacon, or whether they had been introduced just before he wrote. He certainly describes them, and explains why a plane-convex glass magnifies. But he seems to us to speak of them as already in use. "Hence this instrument is useful to old persons and those who have weak eyes."

THE OPUS MAJUS.

The *Opus majus* begins with a book on the necessity of advancing knowledge, and a dissertation on the use of philosophy in theology. It is followed by books on the utility of grammar and mathematics, in the latter of which he runs through the various sciences of astronomy, chronology, geography, and music. The account of the inhabited world is long and curious, and though frequently based on that of Ptolemy, or the writings of Pliny, contains many new facts from travelers of his own and preceding times. His account of the defects in the calendar was variously cited in the discussions which took place on the subject two centuries after. The remainder of the work consists of a treatise on optics and on experimental philosophy, insisting on the peculiar advantages of the latter. The explanation of the phenomena of the rainbow, though very imperfect, was an original effort of a character altogether foreign to the philosophy of his day. He attributes it to the reflection of the sun's rays from the cloud; and the chief merit of his theory is in the clear and philosophical manner in which he proves that the phenomenon is an appearance, and not a reality. Between the two last-mentioned books is a treatise, *De multiplicatione specierum,* entirely filled with discussions somewhat metaphysical upon the connection and causes of phenomena.

Our limits will not allow us to enter further into details: nor could we, in any moderate space, do justice to the varied learning of the author, or distinctly mark even the chief of the numerous singular and now exploded notions which are introduced; nor, as far as we know, does there exist any full account of the contests to which we can refer the reader.

THE STORY OF THE BRASS HEAD.

The following amusing extract will show the sort of reputation which Roger Bacon had acquired:

"How Friar Bacon made a brazen head to speak, by the which he would have walled England about with brass.

"Friar Bacon reading one day of the many conquests of England, bethought himself how he might keep it hereafter from the like conquests, and to make himself famous hereafter to all posterities. This (after great study) he found could be no way so well done as one; which was to make a head of brass, and if he could make this head to speak (and hear it when it speaks) then might he be able to wall all England about with brass. To this purpose he got one Friar Bungey to assist him, who was a great scholar and a magician (but not to be compared with Friar Bacon), these two, with great pains, so framed a head of brass that in the inward parts thereof there was all things like as in a natural man's head: this being done, they were as far from perfection of the work as they were before, for they knew not how to give those parts that they had made motion, without which it was impossible that it should speak. Many books they read, but yet could not find out any hope of what they sought, that at the last they concluded to raise a spirit, and to know of him that which they could not attain to by their own studies. To do this they prepared all things ready, and went one evening to a wood thereby, and, after many ceremonies used, they spake the words of conjuration, which the devil straight obeyed, and appeared unto them, asking what they would. Know, said Friar Bacon, that we have made an artificial head of brass, which we would have to speak, to the furtherance of which we have raised thee, and, being raised, we will here keep thee, unless thou tell to us the way and manner how to make this head to speak. The devil told him that he had not that power of himself. Beginner of lies, said Friar Bacon, I know that thou dost dissemble, and therefore tell it us quickly, or else we will here bind thee to remain during our pleasures. At these threatenings the devil consented to do it, and told them, that with a continual fume of the six hottest simples it should have motion, and in one month's space speak, the time of the month or day he knew not: also he told them, that if they heard it not before it had done speaking all their labor should be lost; they, being satisfied, licensed the spirit for to depart.

"Then went these two learned friars home again, and prepared the simples ready, and made the fumes, and with continual watching attended when this brazen head would speak. Thus watched they for three weeks without any rest, so that they were so weary and sleepy that they could not any longer refrain from rest. Then called Friar Bacon his man Miles, and told him that it was not unknown to him what pains Friar Bungey and himself had taken for three weeks' space, only to make and to hear the brazen head speak, which, if they did not, then had they lost all their labor, and all England had a great loss thereby: therefore he entreated Miles that he would watch whilst that they slept, and call them if the head speak."

Miles then begins his watch, and keeps himself from sleeping by merrily singing.

"After some noise the head spake these two words, *Time is.* Miles, hearing it to speak no more, thought his master would be angry if he waked him for that, and therefore he let them both sleep, and began to mock the head. . . . After half an hour had passed, the head did speak again two words, which were these, *Time was.* Miles respected these words as little as he did the former, and would not wake them, but still scoffed at the brazen head, that it had learned no better words, and have such a tutor as his master. . . . Miles talked and sung till another half hour was gone, then the brazen head spake again these words, *Time is past,* and therewith fell down, and presently followed a terrible noise, with strange flashes of fire, so that Miles was half dead with fear. At this noise the two friars awaked, and wondered to see the whole room so full of smoke; but that being vanished they might perceive the brazen head broken and lying on the ground. At this sight they grieved, and called Miles to know how this came. Miles, half dead with fear, said that it fell down of itself, and that, with the noise and fire that followed, he was almost frightened out of his wits. Friar Bacon asked if he did not speak. Yes, quoth Miles, it spake, but to no purpose; I'll have a parrot speak better in that time that you have been teaching this brazen head. Out on thee, villain, said Friar Bacon, thou hast undone us both: hadst thou but called us when it did speak, all England had been walled round about with brass, to its glory and our eternal fames. What were the words it spake? Very few, said Miles; and those were none of the wisest that I have heard, neither. First he said, Time is. Hadst thou called us then, said Friar Bacon, we had been made for ever. Then, said Miles, half an hour after it spake again, and said, Time was. And wouldst thou not call us then? said Bungey. Alas, said Miles, I thought he would have told me some long tale, and then I purposed to have called you: then after an hour after he cried, Time is past, and made such a noise that he hath waked you himself, methinks. At this Friar Bacon was in such a rage that would have beaten his man, but he was restrained by Bungey; but, nevertheless, for his punishment he, with his art, struck him dumb for one whole month's space. Thus the great work of these learned friars was overthrown, to their great griefs, by this simple fellow."—From *The Famous Historie of Fryer Bacon.*

THE TWO BACONS.

BY ERNST DÜHRING.[1]

IN contrast to the standpoint of scholasticism the figure of Roger Bacon comes before us as a surprise. In a century of darkness it bears the clear and luminous features of later times, but on account of this very circumstance it failed at first to produce any definite demonstrable effect. It has been rightly said of Roger Bacon that he has been unwarrantably thrown in the shade in favor of his less worthy namesake, Sir Francis Bacon, who stands upon the threshold of the modern era. It is also said with equal justice that the earlier Bacon's energy and judgments in the line of experimental research greatly exceeded those of the author of the *Novum organon*, and that it was only the ill favor of time, which he far outran, that permitted his courage to remain for a while without any effect.

A British monk of the thirteenth century who specialized in the study of mathematics, mechanics and other natural science, as far as these could be acquired from good sources, namely from Arabic and Greek writings, and, unsatisfied with what he was able to learn in this way, applied himself to the best possible source, nature, was indeed an anachronism. He was the greater anachronism that he did not stop at mere recommendations of the empirical method like the Bacon of the sixteenth century, but actually obtained results, among which the best known are his discoveries in the realm of optics. His *Opus majus* ("Greater Work") contains treatises which offer better material then the Chancellor—who, by the way, paraded with more than merely his predecessor's name—was able to offer three centuries later. Moreover history need hardly add what can confidently be assumed from common experience and intrinsic necessity, namely that Roger Bacon was the victim of the worst possible persecutions, and even in his last years was compelled to undergo a ten year imprisonment. It is not even known positively whether he was freed from prison a short time before his death, which took place about in his seventy-eighth year (1292), or whether he died in prison.

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[1] Translated by Lydia G. Robinson from the author's *Kritische Geschichte der Philosophie.* Dr. Dühring is known for his clearsighted views and his trenchant style, bringing out weak points to the very limit of fairness.—Ed.

As we have already said, Roger Bacon was not able to bring about all at once a revolution in what to him was most important of all, but in a negative way he succeeded in undermining scholasticism to a considerable extent apparently even in the eyes of his contemporaries, and at the same time directed a blow against the wavering structure which provided an important precedent for its later collapse.

Roger Bacon had studied and investigated for twenty years before he wrote down his now famous extensive works. That he wrote them down at all was due to an external inducement, namely a commission from Pope Clement IV. This order of the year 1266 is the only positive favor fate ever bestowed on this man, who was annoyed by those immediately above him in position and soon afterwards directly persecuted by later popes. He had despaired of ever being able to hand down to posterity the results of his studies and therefore he seized this opportunity with revived enthusiasm because it promised his labors a greater consideration from without, and at the same time, as he was well aware, a secure route to later generations.

Under the name of the "Greater Work" (*Opus majus*) he arranged in systematic order a number of highly important and comprehensive treatises. He began with excursions on the "obstacles of knowledge," described the inaccessibility of the means of research, and presented all the single results which he had attained in the realm of the various special sciences. Reforms in theoretical and practical optics, as well as in chronology and the calendar, played a leading part in his investigations. Besides the *Opus majus* he composed at the same time a "Smaller Work" (*Opus minus*) and a "Third Work" (*Opus tertium*) by means of which he intended partly to promote the clearness of the greater work and partly to fill up gaps in it. Much that he left out in the first place and only succeeded in formulating properly during the progress of the newer work was in this way included in the two later writings.

Until 1859 only the *Opus majus* was accessible in print, but in that year the manuscripts of the two other works were edited in the official collection of writings important for the medieval history of England (*Rogeri Bacon opera quaedam hactenus inedita* edited by J. S. Brewer, London, 1859). For a view of the author himself the *Opus tertium,* contained in the first volume of this edition, ought to be the first considered, since the *Opus minus* can not be regarded as authoritative because the manuscript upon which it is based has been greatly corrupted by the copyist. All three writings were begun and completed within less than a year and a half (1266-1267), a fact which if it were not positively confirmed in many quarters would surely be doubted by all who can not conceive how the preparation of an entire life must indeed have enabled a man of Roger Bacon's caliber to present with great rapidity the range of his thought and the substance of his knowledge.

This phase of his achievements is certainly conclusive evidence of his power, and indeed the more so since one who had studied and reflected so long without putting his thoughts on paper can not be suspected of any inordinate love of writing. To him the thing of greatest importance was to obtain a particular knowledge peculiarly his own, and he did not apply himself to authorship until he could have before his eyes with good reason the prospect of an actual medium of communication.

He exhausted his money in the pursuit of his studies, and, as he himself relates in the *Opus tertium,* spent two thousand pounds —an enormous sum for that day—on instruments, books, tables and apparatus. Such scientific conduct was indeed an anomaly in those days. One might obtain wisdom with less trouble and money if he would move in circles of scholastic argument, or, what would be really worse, tuned the strings of emotion to mysticism and wound them a little too tight.

Roger Bacon occupies an isolated position, but he is the only one in the middle ages who deserves the name of philosopher. The fact that in the year 1267, almost six and a half centuries ago, a Franciscan monk at Oxford was able in from fifteen to eighteen months to outline in three simultaneous works a comprehensive picture of the scientific defects of his day, of the needs for an actual reform, and of his contemplations and knowledge which were far in advance of his time, and in this work to betray a power and scope of mind to which every age can point with satisfaction—this isolated fact we must regard as a signpost to the modern era, and is alone suited to represent criticism of the middle ages on its own ground. No nominalism ever reached so far as the actual craving for knowledge of this indefatigable student and thinker. In language not overburdened with imagery, like that of the second

Bacon, but the simplest which most naturally belongs to interest in a definite purpose, Roger Bacon developed in his three mutually explanatory works the opinions and knowledge which he regarded as the preliminary conditions of a scientific reform and offered as the fruits of his twenty years of study.

Bacon rightly appreciated the contrast between realism and nominalism since he perceived that there was only a difference of terms in this most celebrated point of controversy in the so-called philosophy of the middle ages. In general he treated with the most decided contempt the logic in use which in his time formed the pride of scholasticism. He regarded it as absolutely barren. On the other hand he never tired of recommending mathematics as the basis of all positive knowledge, and as the true *organon* of knowledge. In this respect he hit exactly upon a truth which even after three more centuries the second Bacon missed altogether.

We can not here discuss in detail the discoveries and theories of natural science, especially in optics, at which Roger Bacon arrived by his own application of those principles which he recommended to the rest of the world as the correct method. The way in which he conceived the transmission of light in different substances, and especially the general theories on the communication and mode of operation of natural forces in space which he perfected bear witness even to-day to the depth and keenness of his intellect and in many directions yet untried offer better stimulus to investigation and thought than all the speculative, or rather fantastic, so-called nature philosophy of Schelling, Hegel, and others of their kind. Roger Bacon evidently possessed in almost equal measure the faculty for observation and experiment on the one hand, and for deductive thought on the other. Nor did he by any means ignore the thought of the past for the sake of an exclusive observation of nature, but by means of a fundamental use of classical literature laid down the program of the revival of a better knowledge which was actually carried out afterwards in the course of history.

The languages were to him next in importance to mathematics as means for obtaining knowledge, and he entertained the highest hopes of replacing, if possible, by an adequate understanding of the original works the bad translations whose worthlessness he depicts in interesting detail. He had long applied himself to the attainment of a number of languages and to the construction of their grammar. His use of Aristotle's Physics, which in his day became accessible for the first time, proves among many other things that he not merely had recommended the study and understanding of the sources in their purest form as the means of salvation from medieval ignorance and superficiality, but had himself first made use of all the means at his disposal.

The view that has been praised in recent times as a high degree of philological wisdom, namely, that the corrupted texts and worthless translations of the middle ages had prevented the world from obtaining proper profit from the ancient traditions, and especially from Aristotle, has perhaps never been represented with such zeal as by Roger Bacon himself for whom an opinion of this kind was well founded. For since he observed how many superficialities in the thought of his time could be removed merely by obtaining the proper meaning from ancient authors, especially from Aristotle, he was not wrong in expecting important elucidations from the better philological treatment of the scientific literature of the past.

On the other hand he must have discovered from his own experience and proved by his own example how comparatively poorly a better understanding of Aristotle would succeed in scattering the scholastic mists. Indeed, Roger Bacon's attitude towards Aristotle furnishes a silent and unconscious critique of the position of the entire middle ages with regard to the Stagirite.

In spite of his ready recognition of the esteem which Aristotle enjoyed, yea, even in spite of positive efforts to gain something useful from that author's writings on the philosophy of nature, still Roger Bacon had not the slightest hesitation to theorize with entire freedom according to his own observations and experiments and to bring counter evidence against the principal fundamental ideas of Aristotle. There was no question of a real authority, in the meaning of the word then current, and the rejection of syllogistic logic as an entirely superfluous framework for the attainment of knowledge also bore witness to but a slight dependence on Aristotle.

The reason for this free and independent attitude was the circumstance that the same force dominated Roger Bacon which later became the firmest support of modern scholarship and even to-day provides the most certain guarantee of the triumph over the last medieval mode of thought. The spirit of scientific research, yes in a certain sense even a scientific mode of thought, formed a nucleus for the endeavor of that Bacon of the thirteenth century, and it was only because of this that he was able with few exceptions to tower above the prejudices of his time, to become a true critic of its principal shortcomings, and to prophesy correctly the means by which the future would triumph over the prevailing ignorance. The modern revival of the scientific spirit has indeed advanced along the two highways whereon Roger Bacon had done everything for himself and had attained all that could possibly be hoped for from the strength of one genius relying solely upon himself.

THE SECOND BACON.

It was once a universally accepted view, although it is now strongly contested in the circles of natural science, that Lord Bacon of Verulam was the pioneer in modern scientific method and natural science. Since he was at the head of English philosophy and a generation earlier than Descartes—who on the continent is usually placed beside him—he was even regarded as the founder of modern philosophy. Fortunately, however, even before it was actually rejected, this view was moderated by a contradictory claim in its consequences. Although the questionable rôle of Bacon remained uncontested until very recently, yet speculative philosophers who did not favor empirical knowledge clung firmly to the view that Descartes was the founder of their method, and from this point of view they chose to represent him as the father of modern philosophy, so to speak. On this point authorities were divided and the notion became generally current, and is still held in many quarters, that Bacon was to be looked upon as the originator of modern empiricism and Descartes as the first representative of the modern style of speculative philosophy. Historians decided according to their own preferences for the one or the other line of thought, which of the two men should be regarded as beginning the modern era. The difference of a generation by which Bacon preceded his continental rival might indeed strengthen the claims of his own adherents but was not great enough to prevent the policy of the opponents of this standpoint.

From the standpoint of present-day criticism Bacon must be regarded as having inspired an increase of useful knowledge and a kind of research directed towards the rougher part of natural science. In this connection the Briton has brought to definite expression the specifically English tendency to the hard and tangible, and in this respect he forms the most pronounced contrast to the nature of the criticism which later grew up also on British ground, but which, as may well be taken into account, appears in its finest results as the fruit of the Scottish and not the specifically English intellect.

Francis Bacon of London (1561-1626) was a younger son and hence was obliged to make up in a career what he lacked in inheritance. In fact after a juridical preparation he finally brought it about by the ruthless pursuit of his purpose that he was made Keeper of the Great Seal and Lord Chancellor. Of more service to him than his birth, which was in the same rank, or than the circumstance that his father had been Keeper of the Great Seal before him, was the passion with which he himself pursued these offices and the money connected with them. He had to contend against great obstacles, and his successes did not begin until James I ascended the throne, but after that they increased with extraordinary rapidity and finally changed to an abrupt fall from the greatest height which left him no recourse but to spend five years in scientific leisure.

He entered Trinity College, Cambridge, at the age of thirteen. After studying three and a half years he accompanied the ambassador Paulet to France to get some training in affairs. The death of his father in 1580 obliged him to return. Then, when about twenty years of age, he applied to the government to furnish him with resources in the form of a definite capital, that he might be able to devote himself undisturbed to literature and politics. The failure of his suit obliged him to enter upon the practice of law, and he is said to have been not altogether unsuccessful as an attorney. What most prevented him from rising in his profession seems to have been the disfavor of Burleigh, whereas the Earl of Essex advanced his cause in the friendliest way and took his side at every opportunity. He gave him material support and even presented him with an estate. Bacon later rewarded all these benefits in a very singular and dubious fashion. When Essex's affairs likewise were in a bad way Bacon took an interest in them. Essex too had previously taken an interest in his. In this particular everything corresponds exactly. Only there is a certain difference which the most well-disposed historians and biographers have not been able to regard as insignificant, for Bacon had taken such an interest in the affairs of his noble and high-minded friend, that when he saw him in disfavor and in danger he drew up the accusation against him, performed the services of an attorney in this regard, smoothed the path of the noble man to the scaffold to the best of his ability, and finally undertook to defame his memory as an author.

Those who still try to palliate to some extent Bacon's behavior on this occasion, cannot bring forward any argument but the fact that he was naturally good natured and could not have practised such treachery except from weakness. We do not think that the color of the blot is changed materially by this means. At all events that kind of morals which combines a certain sort of good nature with the ability to treat others in the meanest and lowest way is a very familiar phenomenon. In the meantime we may well reflect whether evil which has its origin in power and the will directed with definite consciousness towards obtaining power, bears any less contemptible a stamp than an act of selfish baseness resulting from weakness. The complete contrast in every sense to what is noble or great in conduct towards man—this contrast in the direct form of behavior which the people unhesitatingly called infamous has been determined in Bacon's character for all time, and even the comparatively favorable way in which a Macauley treats him in his well-known essay cannot avoid an accusing judgment. All that can be attempted to save Bacon's name is simply to let the life of the man withdraw behind his scientific accomplishments.

The dishonor which Bacon morally heaped upon himself by his behavior towards Essex, but which seemed to have been the first step towards really dedicating him to the achievements of a career, was followed, so to speak—though not until late—by an avenging punishment which was the more grievous to a rougher temperament. At first, however, the different promotions up to viscount and the attainment of influential official positions up to those previously mentioned of keeper of the great seal and lord chancellor followed rapidly upon each other after 1603. All these successes are readily accounted for by his unconditional pliancy towards Buckingham, the flippant and unprincipled favorite who well knew how to reward his creatures. Nevertheless parliament took advantage of a favorable opportunity (1621) to give expression to the universal disapproval of the Lord Chancellor and to bring about through the Upper House his conviction for many corrupt practices.

To be sure the sentence was for the most part merely nominal. The enormous fine of forty thousand pounds was at once remitted by an act of clemency. His imprisonment in the Tower, to which he was condemned as long as it should be the king's pleasure, is said to have lasted two days as a matter of form. Hence all that continued in effect was the loss of offices and dignity and expulsion from parliament, and he was also forbidden to appear at court.

But even in these points he was for the most part gradually reinstated and was granted a pension. Nevertheless the stroke had been too heavy, and Bacon made no further attempt to appear again on the external stage but continued to give as much rein as possible to his fondness for ostentatious splendor in domestic affairs.

The corruption in which he had been implicated finds its explanation in his avarice which had been greatly augmented by his excessive extravagance. His financial affairs were never in order because, whether he occupied an official position or not, he sought from the start to keep up a degree of splendor out of all proportion to his resources not only when his income was meager but even at the zenith of his prosperity. At any rate there is not the slightest doubt about his heavy indebtedness, since he himself admitted it as a matter of course in order to prevent discussion of the single scandalous details.

He was as boastful in scientific matters (and often very clumsily so) as he was ostentatious in his domestic affairs. The pompous title which he gave to his first youthful sketch on the transformation of knowledge, which according to his own date he wrote when about twenty-six years of age, looks more like vanity than pride. He called it "The Greatest Birth of Time" (*Temporis partus maximus,* not *masculus* as the title of one of the essays in the published editions reads).

In this respect he ended as he had begun. When ill and conscious of his approaching death he declared in a letter that he was dying as a martyr to science, like Pliny the elder. And yet he had not in the least exposed himself consciously to a great danger as Pliny had done, but very accidentally contracted a severe cold when stuffing a hen with snow in order to discover what effect that would have in retarding decomposition. Moreover he had already reached his sixty-sixth year and had had earlier in life a better opportunity to suffer martyrdom for science by very humble actions, for instance by sacrificing his fondness for luxury and by abandoning the advantages of a more than thankless and corrupt conduct.

Bacon's first publication, which at once established him as an author, was his *Essays* (1597). They are popularly written and contain an excellent philosophy of life, and are read in England at the present time and continue to be reprinted in new editions. In the Latin translation made by Bacon himself they bear the title "Sermons of a Believer" (*Sermones fideles*). The treatise on the dignity and increase of the sciences (1623) had a predecessor in the English language (1605) with the title *The Advancement of Learning.*

As a rule Bacon seems to have usually worked things out in English and then translated or provided for a translation by his friends. On the other hand *Cogitata et visa,* published as early as 1612, seems to have been the basis for the *Novum organon,* the other main work of the *Instauratio magna,* which appeared in 1620. The *Novum organon* itself is said to have been worked over twelve times before it appeared. It forms the most important work from a scientific standpoint, and of all Bacon's writings it is equalled in general significance and effectiveness only by the above-mentioned popular *Essays.*

We need say nothing here of his publications on law and history. It would be an equally fruitless and tedious waste of space to undertake, as many do, to go through Bacon's very indifferent encyclopedic classifications and divisions of knowledge, but we will only indicate the contents and the interconnections of his main works so far as is necessary.

The ardor, we may as well say the violence, with which Bacon had entered upon the external tasks of his life, is reflected in the style and contents of his writings. Even in the realm of logic and scientific methods his language abounds in figures and expressions of poetic color and warmth. It would fain enchant, but usually degenerates into too great an exuberance. It obeys the rein of fancy and of inflated emotion, even where a moderation of such profusion is demanded by the nature of the subject.

Perhaps a large part of the influence which Bacon acquired over the minds of men and especially outside of his own country may be charged to the fascinating style of his effusions. Nevertheless we must not overlook the comparatively unnatural affectation of this manner which puts on the color very thickly and in so far at any rate corresponds to the crude and clumsy object whose picture is to be drawn. But this intrinsic harmony between the vain man and his highest purpose on the one hand and the appearance of his literary garb on the other must not deceive us with regard to the discord in which both stand with the nobler type of what is true and in accordance with nature.

Useful knowledge is to be increased by observation and experiment and thus the power and dignity of mankind will be enhanced. The fundamental idea which guides the philosopher in this respect is in fact the same as that with which the British nation has been imbued up to the present day. It is an idea which arises quite automatically whenever material considerations are dominant and is never lacking where the force and magnitude of external life preserve the balance over all other interests by means of cultural relations. In the face of this principle, the scientific method is not the thing of first importance, but merely a consequence of the main factor. The technical and practical triumph is the end in view, and man's impulse to increase his power over nature and his fellow beings is the motive cause.

This explains both facts and theories. It is the pivot around which Bacon's imagination constantly turned. In life he strove after power for himself and practised the arts by which the higher offices could be procured. In science he felt obliged to preach to the human race a similar line of conduct, namely to follow the grossest means of research with absolute disregard of all the nobler motives for acquiring knowledge. He cared nothing for relations with more ideal interests. He assumed that men would have to waive the incontestable consciousness of intellectual supremacy in favor of the material extension of power. He gave little heed to all the ideas about life and the universe, or rather in his opinion they shrivelled up into an arena for the great art of the "useful," in the coarser sense of the word.

When we read his vigorous aphorisms and comprehend his expressions on the lamentable condition of his time we may deceive ourselves for a moment with regard to their true meaning and scope. All knowledge, he says derisively, rested hitherto on about six brainlets (*in sex hominum cerebellis*). The only hope, we read in one of his best known utterances, is to be placed in true induction. Who to-day would not fully agree with the general import of such an idea? And yet what a narrow interpretation the fundamental principle just quoted bears in the mind of the author of the *Novum organon*!

The history of science has for several centuries endorsed the notion that the expansion of the human horizon must proceed from the inductive method, and in certain unprogressive domains it is even to-day looking for decisive results from the application of this truth. Yet the method in which Bacon thought he had pointed out the way and the means for the increase of knowledge has only a very remote and superficial similarity to the inductive method from which the results of modern science are derived.

The "New Organon," as its title indicates, was to accomplish what men had striven in vain for a number of centuries to attain by the aid of the old *organon,* i. e., the logical writings of Aristotle.

An instrument of knowledge was to be constructed which would bear better fruit than the conceptual fabric of the scholastics and their ancient masters which revolved in a circle and was despised by all the world. The barren syllogistic of Aristotle was to give place to systematic methods in which experimental research would have to proceed. This in itself was a great task—so great that to the present time only a very small part can be regarded as settled. But the solution Bacon originated is coming more and more to be definitely recognized as a mistake which soon could no longer count as anything positive.

Nevertheless in the face of these facts which we regard as undoubted indications of error and inadequacy, we must be just to the merits of Bacon's works which lie in a different direction. Wherever the actually deplorable condition of learning and the causes by which the attainment of positive knowledge is hindered are to be described, there Francis Bacon has found his proper place. The feeling of the impotence of previous scholarship and of the consequent human degradation was so strong and vivid in him that it lent a great charm to his presentation of the *idola* which hinder progress. He took this stand in the first parts of the *Novum organon* as directed against a vast number of prejudices and customs among which the errors of learning are also suitably treated. Pedantry is condemned with fine scorn, and the single expression "professional habit" (*mos professorius*) means at least as much in the mouth of the man of the world or of business as the pertinent characterization of *idola*, especially the so-called shadow pictures of the cave (*idolon specus sive cavernae*).[2] By the latter very obvious expression Bacon sums up in this case all the individual limitations originating partly from submersion in the narrowness of an isolated vocational life hemmed in by an ignorant tradition.

Different classes of idols are here displayed, and the theory of these illusive forces and these idols whose cult hinders the progress of true science is well worth reading and taking to heart to-day. Likewise where Bacon turns upon the prevalent metaphysics, the daring of his conceptions deserves our sympathy even to-day whenever he points prophetically to the vain and futile systems which would be proposed in the remotest future. The perusal of the brief portion of the *Novum organon* devoted to general conceptions might still serve in certain quarters as means towards intellectual liberation. Just because we are separated from the author by several centuries, the stimulating effect of his general descriptions is often all the greater. In these characteristics there lies something of the restless impulse which is manifest in our own century.

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[2] Compare Plato's Republic, VII.—Ed.

In Bacon's eyes printing, gunpowder and the mariner's compass had already pointed the way to goals of modern power and greatness. He would have naught to do with those dry controversies which bore no fruit for human mastery over things but only for the position and purse of the professors. For this reason he rejected the syllogistics of Aristotle as totally barren, and opposed authority in general, which is wrongly conceded to the traditions of antiquity. On the river of time it is likewise the lesser weight which floats on top of the water, and so it is exactly the lighter and less valuable material which has been washed up while the heavier and more significant has gone to the bottom. The works of an Aristotle are preserved, while those of a Democritus and Empedocles and others who were occupied with the true knowledge of nature have been lost. The great significance which is generally attributed to the accomplishments of the past is one of the chief reasons for the impotence of the present.

Lord Bacon conceived the idea of a reformation of science as a whole, and in later years he liked to regard it as "a strange sort of fate" that although he "had labored for the sciences more than for all else, yet he had been torn away to business matters and a public life."

A certain encyclopedic current in those times need not surprise us. In the comparatively narrow limits of the science of those days universal combinations of the whole domain do not yet appear as unsolvable tasks. Therefore we need not wonder that the possessor of that proud consciousness of his own calling devoted the work of the *Instauratio magna* not only to present the actual condition of knowledge in all quarters but also actually to blaze a new path and to show not only the method recommended but also its results.

The complete work, of which the *Novum organon* is only one part, has remained, it is true, without a conclusion. Even the title of the main part which appeared first, "On the Dignity and Enhancement of the Sciences" (*De dignitate et augmentis scientiarum*) is characteristic. Nevertheless the *Novum organon,* which follows as the methodological basis, must be looked upon as the work properly representing Bacon's philosophy. It is not the universal scholar and his encyclopedic effort that we are interested in, but the methodizer and the impulses towards empiricism that he originated.

As previously indicated, Bacon's epistemology is of far greater negative than positive significance. He formulates correctly the contrast between the Aristotelian method and the requirements of a genuine increase of knowledge. In this connection he gives expression strikingly and drastically to what the approach of the modern era had made perceptible before his time in the most diverse quarters and to what Telesius Cosenza (1508-1588), for instance, whom Bacon valued highly, had really represented.

Nevertheless his struggle against Aristotelian logic does not agree entirely with the general conflict in which at that time the progressive party of the scholars and philosophers engaged against the validity of that authority. Bacon directed his attention with good effect against the two chief failings of the Stagirite. He explained as unavailing the syllogistic connection of thoughts on the one hand, and on the other the explanation of nature by the introduction of the concept of purpose. The kind of observation which took pleasure in searching after the purposes and intentions of nature's operations he compared to a divinely consecrated virgin who does not give birth to a child. However, he thought that what is met with in Aristotle as so-called induction is not at all rational as true induction; that it refers only to the enumeration of cases and therefore may be found in the crudest beginnings.

The positive part of the *Novum organon* presents the several ways in which according to Bacon's idea research must be reformed in order to obtain results scientifically. And yet his enumeration of a large number of possible situations and applications of analytical thought is itself neither methodic nor adequate. The cases for and against the combination of two properties or phenomena are for instance to be brought together in order to be able to pronounce judgment for or against the affinity (e. g., of light and warmth) according to the overwhelming accumulation of data. If one can not deny that the whole systematization is able to exert a stimulating effect in many directions yet the actual result is almost nothing. The very thing that is most important in the strict science of to-day is not even taken into consideration. That there can be such a thing as an experiment possible only on the basis of genuine speculation is not recognized in the least.

If we seek a reason for these errors we are confronted with two possibilities. On the one hand there is even yet no separate theory of inquiry in which authoritative schemata for the intellectual function would be proposed in such a way as to be recognized by naturalists as adequate and useful, and by logicians as rational and systematic. On the other hand the assumption is most widespread among the positivists that such a theory of inquiry could not accomplish anything aside from the quite general ideas of observation and experiment. It is not possible, they say with some reason, to replace the practical foresight of the thinker and student once for all by a collection of universal applications and formulas. Now those who proceed from this hypothesis will find the errors of the positive attempts of the *Novum organon* quite in order. They will prophesy a like failure for the efforts of every one who to-day would undertake a similar task.

But now it will be urged against this that within strict science itself—although in the garb of typical instances—scientific principles and applications of the most general interpretation have been laid down, and that it only requires a similar genius to create an adequate and useful theory of inquiry upon the basis of these partly concealed elements.

It is true that but few instances of this kind were at Bacon's command, and, what is worse, these he could not utilize with his type of mind and his knowledge. Since he had not the slightest comprehension of the rôle and scope of mathematics in generating knowledge he was compelled to remain behind even that which the first Bacon three centuries before him had recognized as a scientific necessity and had applied successfully. In this defect in mathematical and mechanical thought the man who presumed to point out the paths of the future by his own method completely misunderstood the greatest attainments of the past. He ridiculed as a manifest folly the Copernican system which had been made public a few decades before his birth. He represented the falsest notions in mechanics, and even ignored Archimedes's law of the lever at the very time when the foundations of modern dynamics were being laid by the almost contemporaneous Galilei.

But what Lord Bacon could not accomplish and what no one will be able to do in the future who does not recognize positively the significant part played by mathematical and quantitatively determined calculations and who does not regard them as a universally authoritative principle, was the discovery of the true scientific principles and the most efficient means of extending positive and fruitful knowledge. He also lacked the slightest conception of that kind of genuine naturalistic speculation which led a Galilei to recognize the law of falling bodies, and without which observations and experiments would not be able to accomplish anything of importance.

Just those anticipations which Bacon rejected are in a certain sense the first and most powerful means by which the understanding penetrates the secrets of nature and marks out the direction in which the decisive questions should be formulated, and wherever possible to have them answered by nature itself by means of artificially arranged experiments. The best part of the theory must in most cases be present before one succeeds in presupposing in a general way facts of a determining kind. Now to be sure mathematical thought is not the only source, though it is the most original source, of all genuine anticipations. Whoever can not appreciate this basis of a safe orientation must misunderstand still more every other class of intrinsically authoritative forces of cognition. The understanding with its power to make *a priori* determinations must remain concealed from him and thus it is easy enough to explain why the *Novum organon* failed in its positive task. Indeed this explanation presupposes in the one for whom it is intended to have any weight certain ideas of the content of strict science and of those intellectual powers by which it has actually become great.

Our account of the causes which prevented Bacon from attaining his main purpose even in the slightest respect is confirmed by the recollection especially of the difference between him and the genius of the same name who preceded him by three centuries in a similar attempt.

Both Bacons took their point of departure from the utter inaccessibility of what science there was and inadequacy of the prevalent methods. Both led discussions on the obstactles which hindered more perfect knowledge. Both attempted a comprehensive encyclopedia of the objects of knowledge but the first Bacon was a positive thinker along mathematical lines who attained incontestable results. He was impelled by a genuine love of knowledge; vanity and ostentation were entirely foreign to him. The practical results of this method can not be disputed. At least in optics and particularly the theory of refraction he made decided progress. He also discovered the combination of gunpowder itself, or at least of something similar to it, as well as the application of such an explosive substance to the ejection of bodies from a tube. But we can not bring up the slightest evidence in this direction with regard to the second Bacon. He did not succeed in making a single discovery, nor has a single application of his method elsewhere led him to any attainment worth mentioning.

Then too if we compare the relative position which both occupied to the centuries in which they lived and worked, there can not be the slightest doubt to-day that that lonesome student of the thirteenth century far outshone the self-satisfied chancellor in this point also. Even those, who, like Hallam, the English historian and expert of the middle ages, value the second Bacon more highly than he deserves have not a moment's hesitancy in recognizing Roger Bacon as the first author of his century. Now no one to-day would make the same claim for the second Bacon, and yet that estimation of his predecessor is far below the truth.

Roger Bacon was not only in advance of his own century but in the most important respect far beyond the entire middle ages, and in some directions, as far as his type of mind is concerned, he even stood on those heights which every era possesses, and on which in all ages only geniuses of the first rank meet and understand each other. Hence he shared in that which towers above the middle level of every era and belongs to that region in which mankind as such, and not merely this or that generation, seeks nobler and truer standards. Whatever pains we may take to praise the scientific Lord Chancellor we shall not be able to win for him so high a position. We must be satisfied if in the face of the nature of his works, which we are now fortunate enough to be able to study more closely, we may claim for him a certain power to stimulate to empirical methods. Even his assault upon the old methods has a negative value, nor can we refuse him the credit of having systematically and extensively classified and exposed certain obstacles and absurdities of human knowledge. Yet in this respect as well he may have been but the imitator of his predecessor. Still the opinions of those who accuse him of directly borrowing from the manuscripts of the first Bacon, and, as for instance Charles Forster, have even printed parallel passages side by side, cannot be considered here. It is known that others also have stolen from Roger Bacon without giving him credit and have even honored him by making literal excerpts. One such passage, for instance, made a deep impression on Columbus and determined his decision without the future discoverer of the new world knowing what genius he had, so to speak, come into contact, and from what century he had received confirmation of his views with regard to a western passage.

Roger Bacon stands too high, and Francis Bacon is of comparatively too little significance for it not to be better to regard the loan question in this case as pretty subordinate, and to save the time which might be spent in exposing plagiarisms for really important theories and considerations.

At any rate the second Bacon did not use his predecessor to the best advantage in the most important point, namely with respect to mathematical and mechanical modes of thought and the corresponding basis of the sciences. A skilful borrower who would have taken up the matter from this side would evidently have made himself more useful to the world than the second Bacon with his *Novum organon,* the alleged instrument of science, in whose construction unfortunately the finest instrument and most powerful medium of knowledge which the human mind possesses remained unconsidered. Nevertheless the Baron of Verulam would fain have lifted the scientific world off its hinges without knowing the law of the lever.

ROGER BACON THE PHILOSOPHER.

1214-1294; 1214-1914.

BY ALFRED H. LLOYD.

HISTORY works many wonders; none, however, more striking than that, again and again exemplified, of the discovery, resurrection, and transfiguration of the forerunner. Doubtless, some day, when America shall at last have produced her great philosophers, a real and really dramatic history of American philosophy will come to be written and the relatively small and insignificant thinkers of past and present, although perhaps long forgotten and never greatly celebrated, may become immortal as forerunners. Think what Socrates, Plato and Aristotle did for the historic line of the pre-Socratic philosophers beginning with Thales or—possibly not so remarkably—what Kant and Hegel did for their forerunners beginning with Descartes. And, to come to the subject of this essay, think what Lord Bacon of the seventeenth century and the natural science whose method he has had the fame of first clearly formulating, did for Roger Bacon of the thirteenth. Can it be that resurrection rather than burial is a law of history?

But there is, of course, a different side to the whole matter, not necessarily flattering to him or those who have followed. In the history of philosophy, as in all history, any day or generation is constantly being found to have, or at least to seem to have, plagiarized from the past. The forerunner, when brought to life and justified by some later thinker, often proves to be, not the dependent or subject, but the master, even robbing the later and widely reputed prophet of his glory. Dr. Jacoby,[1] of the University of Greifswald, lecturing in America a year ago, found most if not all of Bergson in Schopenhauer and with a skill not less successful and scholarly performed certain other similar feats that all but turned familiar history topsy-turvy, making a supposedly dead and ghostly past not merely real and alive but even more real, more vital or at least more original, than the present. Perhaps Greifswald was unwilling that any good thing should rise from the fermentations of Paris, but, again to come to the subject of this essay, of the two Bacons it has been said more than once, not only that the earlier friar was possessed of more insight and originality than the later lord, but also that, while the lord doubtless got his name without benefit of the friar, he nevertheless quietly appropriated many of the other sources of his reputation from his more brilliant as well as more pious forerunner. As to the truth of this charge it must always remain at least a puzzle why there should be so many striking and often almost verbal similarities between the doctrines of the two men; for example between their protests against the authority of the past, of medievalism generally and of the medieval Aristotelianism, between the four idols, or *idola,* of the one and the four *offendicula* of the other; and, not to lengthen the list here, between the prophecy that Francis made of such modern wonders as flying-machines, carriages not drawn by beasts, telephones and submarines and that of the same things proclaimed by Roger more than four hundred years earlier. Perhaps by surreptitiously introducing all those surprising acrostics Francis Bacon did not manage to have written Shakespeare, but he does seem to have been busily writing on passages in the *Opera* of Roger Bacon prenatally by several hundred years. In any case, while resurrection may be one of the laws of history, the later day restoring the earlier, it does seem also as if at least sometimes the past, hearing the great trumpet-call, rose up to the serious if not fatal undoing even of long following generations.

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[1] See also Günther Jacoby, "Henri Bergson, Pragmatism and Schopenhauer," *The Monist,* Oct. 1912.

Still, not on the relative greatness or originality of the two Bacons and their different times must I hold my attention or my readers'. Whichever man one decide to make the support of the other, be Roger Bacon the great genius or only the fortunate forerunner, there is good reason for the present interest in him, and my particular contribution to that interest has to do primarily with his philosophy. Of his philosophy, then, I shall speak under three heads: metaphysics; methodology; moral philosophy.

The metaphysics is notable in at least three respects. In the first place, his substance is no mere stuff or material, whether physical or spiritual, of which things are made by being given some form, say the form of stone or tree or the image of God. It is no mere clay, in itself aimless and lifeless, in the potter's hands. *Mere* material can be no more substantial than *mere* form. In other words substance, *real substance, can lie only in the union of material and form.* So, as I would submit, does the always far-seeing friar say, only in the rather inadequate language of his time, that substance is essentially dynamic or active in its own right or nature, inhering not in the material nor in the idea or form, but in the process by which material takes form or form expresses itself materially or, quite generally, by which universal and particular, being inseparable, work in and through each other. His was thus more a *genuinely* Aristotelian or even a Leibnitzian idea of substance than a scholastic or, to say the least, than a medievally orthodox one. I have added the alternative, because in the doctrine of substance, as well as in many other doctrines, Roger Bacon's philosophy is an emphatic reminder that the Middle Ages were not so blind nor so bound as they have often appeared to be to the casual view, and in general I wonder if, instead of feeling surprise that in men and in ideas the thirteenth century was often alive with what was "ahead of its times," as the phrase runs, one should not rather expect to find in a civilization that did finally outgrow itself living and notable evidences of the coming change.

But, for the second important aspect of the metaphysics, quite consistently with his idea of substance Bacon holds that mere material can have no integrity of its own. There can be no single something, that is, no material *one*, no one stuff, behind all things; a denial, I think, that is directed quite as strongly against any oneness or singleness or say any homogeneity in the spiritual as in the physical realm; for in his vigorous antipantheism Bacon shows himself opposed both to materialism and to monism as explanation of the spiritual world. In fact he seems to me to be here a very true follower of St. Francis himself in that in his feeling or vision, if not in any of his definite statements, he is become virtually indifferent to the differences of the traditional dualism. For him, integrity no longer dwelling in the mere stuff of things, what does it signify whether things belong materially to one realm or the other? Spiritually or physically the material of things is plural, not singular; many, not one. *Quantae res, tantae materiae.* A harder and more destructive blow to the dualist's traditional stuffs, merely of which individuals are made, would be difficult to conceive.

And, thirdly, Bacon the metaphysician, regarding substance as in the union of material and form and insisting that no mere material can have any unity, proceeds to a very logical conclusion, namely, to the assertion of the prior reality of individuals in the world. Universals have no real existence. Whatever claim universals may have to recognition can lie only in the resemblances of individuals. Our metaphysician was thus nominalistic, and in his nominalism, however uncertain and inarticulate it may seem when compared with that of the fifteenth and sixteenth centuries, we have one more evidence of his timely originality and precocity and a door, set well ajar, by which we may pass from his metaphysics to his methodology. With the subordination of the one to the many, of universals to individuals, appear appreciation and advocacy, theoretical and practical, of induction and experiment. Others must tell how much or how little was actually accomplished through these methods. I am to consider here only Roger Bacon's sense for method, and in using this phrase I mean to indicate in a rough way to what extent he may be called a methodologist.

In any reflections on Bacon's sense for method one needs to give very special regard to the times in which Bacon lived. The sophistication that underlies any adequate appreciation of method as method, any clearly conscious and well-controlled adaptation of means to end, can hardly be said to have constituted a conspicuous and pronounced factor in the atmosphere of the thirteenth century. Nor in the cause of the natural genius and timely precocity of that century do we need to look for such mature sophistication. Neither church nor state, neither industry nor social life had reached the deliberation and finesse which that would demand. Machiavelli or at least Machiavellism—for there may be some physiologist near at hand—was still three centuries unborn. Jesuitry was no older. Industrial organization and social custom were waiting—not yet very restlessly—for the Renaissance to make them, first humanistically awake, self-conscious, zestful, and then, as man, conscious of his own worth, should come to demand liberation from all confusion and entanglement with the machinery, the mere instruments and methods, of life, even rationalistic, *resorting, as he finally did to reason and nature that he might escape the constraint of his own institutions.* Chemistry was only alchemy. Astronomy was astrology. The ritual of religion was exorcistic. All of which is to say, I think, that in general the method or the formal organization by which a society trains or educates its members to a sense of method was not yet abstracted and dehumanized. In every department of life society was organized in the spirit of militarism that directly exploited men, their physical strength, their personal hopes and fears, their wants, their habits, their immediate attitudes and ideas, for all the interests and purposes of life. Human life, physical, mental and spiritual, was still both end and means. Of course for man thus to be using his own nature, all its various forces and resources, for development of himself, was to be exhibiting an inefficiency—suggestive almost of the futility of trying to lift oneself by one's boot-straps—that must even provoke a smile in these very modern days of efficiency, but whether in physical or in mental activities, that military way of exploiting human nature, of treating it as both end and means, had at least the value of being educative. Just by being treated in his own person as a corporate part of the method and machinery of life, man acquired, let me say, as the natural outcome of his discipline, the power of himself at once freely and in our modern sense efficiently using method and machinery. He was educated to use for his own purposes forces and resources that were natural rather than human, objective rather than subjective, mechanical and physical rather than military and human. He was made no longer a soldier, but a mechanic; no longer a compliant believer, but a logical thinker; no longer a mere slavish ritualist in any field, but an investigator and experimenter. And so, if the Renaissance be noteworthy as peculiarly the transition period of such a development, Roger Bacon's century can hardly be expected to have produced more than a prophet of it. His own sense for method was indeed no uncertain sign of what was to come, but such ideas as he had are not worked out in those details that insure effectiveness. He, or his methodology, such as it was, only shows that the education of the medieval organization of society was beginning to produce substantial results.

Perhaps it is far-fetched to attach any great importance to the fact that Bacon belonged to one of those orders that must always be thought of as valuable forerunners of Protestantism and that in this character showed a strong disposition, by using the church and its officers rather than being used by them, to turn the existing organization of life into an external means to life instead of continuing to confuse it with the end of life. Also it may be unwise even to make much of Bacon's English extraction. Some importance, however, must belong both to the Franciscan connection and the English extraction, although without them a man very much like our English Franciscan must soon have appeared. The medieval system had already passed the era of its greatest formal successes and for any system this era must soon be followed by the change, already indicated here, but now somewhat differently described, from the system's institutional and dogmatic period to its instrumental and experimental period. Of just this change Bacon's methodology is a sign or, if the metaphor be not too violent, an alembic; and with it, as must now be pointed out carefully, there came also the generalization or the opening of the view that the experimental use of anything in distinction from a use so self-centered as hardly to constitute use at all, or that induction, in distinction from deduction, must always bring. Deduction, for example, is naturally committed to some fixed and special system or law; it is monarchical and institutional. But induction is bound only to a general lawfulness, to an open principle of law in things, being democratic and experimental.

But now I would go even further than suggesting as above I have suggested, that Bacon's appreciation of experiment and induction were products of the medieval system and its educative influences. On one factor of method, as he conceived it, I have not yet touched. To induction and experiment Bacon added mathematics, in his appreciation of this far excelling his follower of the same name and possibly excelling, too, even his own appreciation of experiment and induction. Was the sense for mathematics also in the atmosphere of his century? Was it also an outcome of the medieval organization of society? I have to believe that it was. Possibly, from what has been said already the grounds of this belief will be easily surmised, but mathematics or mathematicalism seems to me very like a liberated legalism or institutionalism. It is a spiritualized and dehumanized, a universalized and objectified legalism. Thus, again, the spirit of legalism with its tests of formal consistency belongs to mathematics in the very highest degree, but in mathematics that spirit has been freed, first, from any one given system or regime, the "given" in any instance always having the character of only one among indefinite other hypotheses, and, second, from human interest and bias, qualitative differences being lost in homogeneity and valuations being all quantitative and being controlled by standardized methods and instruments. An institutional life, then, like that of the medieval church and state, as it passed from an institutional to an experimental and instrumental character, was bound to produce, at least among the more responsive and appreciative members of its personnel, not merely the wider view of experiment and induction, but also the freedom of the mathematical way of reasoning; and Roger Bacon, at once Englishman and Franciscan, was certainly one of the most responsive and appreciative spirits of his time.

For the rest, it is important to keep in mind that, like all else in his philosophy, Bacon's sense for science and its method was more vision than clear and full understanding. He saw much afar off, but, as said here already, in formulating the details of what he saw and in effective and productive application he was lacking. A significant side-light on his methodology is afforded by his sensitiveness to the deficiencies in the scholarship of his time. Not only in the sciences would he have a methodical study of nature, but also in the humanities, notably in the languages and literatures, he would have men go carefully and methodically to the sources instead of using most untrustworthy translations then still in vogue. In his methodology, finally, Bacon was a thinker or seer beyond his times or beyond what appears as the vogue or the surface of them. A stick, however, drawn from the water, must still drip, and in view of this truth, interesting and fascinating to the observer in many ways, it is refreshing and reassuring to find that with all his anticipations of the modern standpoint Bacon was still of his own century, not now because every century of a growing civilization must have its prophets and forerunners, but because he actually mingled the magic of his day with his method, the blind and extravagant expectation with his rationalism. The languages, notably Hebrew, were to be mastered in a few days; the sciences in a few weeks. The Berlitz Method for the languages, "while you wait," and Steele's *Physics in Fourteen Weeks,*—if I have the title right,—are but a far cry from Roger's splendid dreams.

Thirdly and lastly, there is the moral philosophy to be considered. In this, as might be expected, progressivism being always peculiarly reluctant in matters of religion and morality, Bacon is disappointing. At least he is disappointing at first sight. Thus for him moral philosophy is neither more nor less than theology. Science and reason are handmaids of the church. Although such empirical generalizations as he makes in the field of morals are often interesting and show perhaps more than ordinary insight, ecclesiastical tradition appears as a strong bias in them all. So, whatever be true of Bacon the metaphysician and methodologist, Bacon the moral philosopher seems more the medieval friar than the seer and thinker. But he is indeed a poor friar who is not more than his gown, and Bacon proves to be in reality much more even in his moral philosophy, Thus for him moral philosophy or theology is no discipline by itself, aloof and wholly independent;

it is neither more nor less than the crowning science. The term "sacred" he applies not merely to theology but to other sciences, like geography and geometry, and with a meaning that no ordinary theologian of his time could ever intend. Science and reason are for him truly handmaids of the church, but he is also at least near to regarding them as in a *necessary* attendance upon the church and its faith, and, plainly, if indispensable to the church, they have a certain independence. Indeed Bacon sometimes concedes to them a worth quite their own. "We have now considered," he says, at the beginning of the *Opus majus*, "philology, mathematics and experimental science and have observed both their intrinsic importance and their value to the church." With this introduction he proceeds to his moral philosophy or theology, which, as turns out, he would have based on a synthesis—marvelous to contemplate and showing the friar in a large rôle and in danger, too, of an un-Christian if not unholy enthusiasm—of the Mosaic law, Christian revelation, pagan philosophy, and natural science. Frequently he quotes Aristotle, Plato, Cicero and Seneca.

So, after all, Roger Bacon, the forerunner and seer, was by no means altogether lacking in his moral philosophy.

In closing, I would say of Bacon's doctrines at large, of his life and thought as a whole, that such a man of genuine vision and enthusiasm, a man not too successful in understanding himself and in formulating his ideas for others, has an importance that in our own time may easily be underestimated. Also, after finding him and getting knowledge of him, historians must gain new interest and confidence in their studies from the fact that the clear seeing, the rationalism and the mechanicalism, the experimental science and the mathematics of the seventeenth and eighteenth centuries, not to speak of later times and standpoints, had such a worthy forerunner as early as the thirteenth. Without such prophets as Bacon, without such men, able to distill the future from the past, history would surely be a dull and futile science.

ROGER BACON AS A SCIENTIST.

BY KARL E. GUTHE.

IN the history of science of the thirteenth century two commanding figures stand out among all the natural philosophers of their time, Albrecht von Bollstaedt and Roger Bacon. Both have been highly praised as great men, and both have been sneered at as charlatans. Certainly neither of them had a high opinion of the other. Nothing appears to be more difficult than to decide upon the characteristics of a great scientist. In his book entitled *Grosse Männer* Ostwald selected only investigators who had made some remarkable discovery as examples of this type. But to measure all men by such a single standard as Ostwald's appears to me unjust and wholly onesided. I would rather call each of Ostwald's heroes a scientific genius and not restrict the class of great men so as to shut out any one who in one way or another has had a profound influence upon the progress of civilization.

Roger Bacon cannot be credited with a single epoch-making discovery, and yet he deserves to be called a great man. He is one of those rare scholars who combine with a remarkably extensive knowledge and with an admiration for the majesty and mystery of this world a powerful conviction that a certain unity underlies the various phenomena in nature and that all sciences—in their widest sense—are dependent upon one another. Such men attempt to rise above mere details, to view the world as a whole, and then present in bold outlines a picture of the Cosmos as they see it. In many cases their efforts result in the production of a mere cosmic encyclopedia, but for really great thinkers the world of observation blends with the world which they build up in their imagination to a unified picture, though possibly distorted and unreal when viewed by later generations.

We seem to be unable to get at any one time a complete view of this world; in fact our view is constantly changing, and every attempt to chain down the Cosmos has been unsuccessful. In this respect Roger Bacon achieved no more than others have before or after him. His works, like all similar attempts, should be entitled "Facts and Fancies." In view of the meager equipment of facts which the scientific world possessed at that time, fancies play an important rôle in Bacon's treatises. As a source of scientific information his writings are of little value, but as human documents describing the knowledge, beliefs and superstitions then existing, and showing the attitude of scholars towards scientific questions, they are of absorbing interest.

Man has not changed appreciably in 700 years. Much as we now discuss the value or uselessness of certain disciplines, so did men in Bacon's time. Just as at present we often consider any one an ignoramus who happens to disagree with us, and declare another a profound scholar whose views coincide with ours, so Bacon, who was a little more outspoken than is considered proper for a twentieth century professor, considered only one mental attitude towards important philosophic questions to be correct; and this indeed is the attitude which in the present scientific age is shared by many of us. Therefore we are liable to overestimate Bacon's importance in the history of science. He was not generally considered a great man in his own age and for some centuries afterwards, when the methods for searching after truth were different.

How was it possible that a man like Roger Bacon could arise in the thirteenth century? How could he have shaped for himself a world picture so different from that taught in the powerful University of Paris? I do not believe that even a master mind, such as he doubtless was, can create a great thought or state a fundamental truth without considerable preliminary work and study on the part of some predecessors who have at least felt it, though unable to express it as clearly. Indeed, Roger Bacon seems to me to be the product of a perfectly definite movement and—unfortunately for science—its last great exponent for the time being.

It was not until shortly before Bacon's time that Europe became acquainted with Arabian scholarship which itself was a product of the cultures of Greece and India. While the Arabs preserved and taught Greek philosophy, they were mainly interested in the purely scientific results of Greek scholarship and laid special emphasis upon the development of the mathematical sciences.

It seems that a revival of mathematics occurred first in England. Adelhard of Bath who had traveled among the Arabs for purposes of study, translated upon his return to England in 1130 the Elements of Euclid; Jean of Holywood wrote a book on arithmetic, and Robert Gross-tête, later bishop of Lincoln, was greatly interested in mathematics and the sciences. So was Adam de Marisco. The last two, Roger's teachers of whose learning he speaks always with the greatest respect, must have been powerful and original minds and must have made a lasting impression upon the younger scholar.

Bacon was thus a product of a school of mathematics and formed his world picture accordingly. While he acknowledges the value of the languages—namely in order to avoid mistranslations—he says of mathematics: "He who knows not mathematics cannot know any other science; what is more, he cannot discover his own ignorance or find its proper remedies. So it is that the knowledge of this science prepares the mind and elevates it to a well authenticated knowledge of all things."[1]

This statement which seems highly appropriate as applied to physical sciences, refers, however, not only to the sciences proper, but to theology as well, as he explains at length in his *Opus tertium*: "Without mathematics we can not fix the dates of sacred history nor can we see the true relations between celestial and mundane occurrences."[2] Without geometry we cannot get a clear idea of the shape of Noah's ark, or of the tabernacle. Without arithmetic we cannot understand the symbolic meaning of the Trinity. Since at his time mathematics included also the science of music, he adds as further argument, that without music we know nothing about hymns and invocations of spirits. A large portion of the *Opus tertium* is devoted to a discussion of the beneficial and elevating influence of music and rhythmical art. It may appear peculiar that Bacon places so much emphasis upon what might now be considered as trivial; but it should be remembered that these very things frequently formed the subject of highly learned disputations among Bacon's colleagues.

This man, so strongly convinced that mathematics forms the very foundation of all knowledge, went to Paris for further study; and what did he find? The far famed illustrious teachers of that time—Albertus Magnus, Thomas Aquinas and others—were interested in entirely different things. In Roger's estimation they could not compare with his former teachers who according to him were perfect in divine and human wisdom. The shortcomings of the Parisians he could easily explain by asserting: "The neglect of mathematics for thirty or forty years has nearly destroyed the entire study of Latin Christendom."[3]

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[1] *Opus majus,* pars IV ("Mathematicae in divinis utilitas," distinctio prima, ch. I): "Quoniam qui ignorat eam non potest scire caeteras scientias nec res hujus mundi, ut probabo. Et, quod pejus est, homines eam ignorantes non percipiunt suam ignorantiam, et ideo remedium non quaerunt. Ac per contrarium hujus scientiae notitia praeparat animum et elevat ad omnium certificatam cognitionem."

[2] *Opus tertium,* ch. XI: "Nam planum est quod sine mathematica non possunt sciri coelestia: et coelestia sunt causae rerum inferiorum, et causata non possunt sciri sine causis suis."

In disgust he turns away from his unsympathetic colleagues. He speaks in praise of only one person, and him indeed he calls a perfect mathematician. This man was a Picard by the name of Peter de Maharncuria. For many years historians have tried to identify him; Charles has shown him to be no other then Peter Peregrinus, the well-known writer of a letter on terrestrial magnetism and the compass.[4] This scholar was not a teacher in Paris, but an independent investigator, and apparently little known.

A man like Bacon would certainly be much interested in physical problems, and indeed he found great pleasure in the study of light which subject was at that time restricted to geometrical optics. In this field also he finds nothing in Paris. Twice there had been lectures in Oxford on light, but not once in Paris. Listen to his complaints about the conditions in the latter institution. "The man who pretends to be an authority in optics, knows nothing about its value, as clearly appears from his books; because neither has he written a treatise on this subject—and he would have done so, had he had the knowledge—nor has he said anything about it in other books." And then in his characteristic manner he closes with the words, "and therefor he cannot know any thing about philosophy."[5]

It is difficult to describe the peculiar charm which we find in the study of Bacon's works. We modern scientists are so accustomed—and I believe properly so—to eliminate our own personality from our work, that our world has become one without feeling, that it speaks to us only through experimental facts. In Bacon's writings it is all so different. Those old scientists took no interest in the game when they eliminated sentiment and animosity from their discussions. At times it is almost uncanny to feel the old monk sitting right by your side and pleading with you in such a personal and direct manner. One can not help fearing that one's estimate of his proper place in the history of science might become warped by sympathy for him. It is difficult not to be persuaded that the great Albert was after all an impostor, wholly unfit to be a professor in the great university. And yet, Bacon's estimate of his great scholastic contemporaries was certainly too harsh.

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[3] *Opus majus,* pars IV, ch. I: "Et harum scientiarum porta et clavis est mathematica.—Cujus negligentia jam per triginta vel quadraginta annos destruxit totum studiûm Latinorum."

[4] A full account of this important work is given in Benjamin's *The Intellectual Rise in Electricity,* pp. 165-190.

[5] *Opus tertium,* ch. XI: "Haec autem scientia non est adhuc lecta Parisius, nec apud Latinos, nisi bis Oxoniae in Anglia; et non sunt tres qui sciant ejus potestatem: unde ille, qui fecit se auctorem, de quo superius dixi, nihil novit de hujus scientiae potestate, sicut apparet in libris suis, quia nec fecit librum de hac scientia, et fecissit si scivisset, nec in libris aliis aliquid de hac scientia recitavit.—Et ideo non potest scire aliquid de sapientia philosophiae."

We must not forget that science had just been revived in the Christian world. In 1209 the study of the books of Aristotle was forbidden; in 1215 Robert de Courçon, a papal legate, renewed the prohibition, expressly including Aristotle's metaphysics; in 1231 a bull of Gregory IX modified this decision with the proviso that the prohibited books were not to be used until they were proved to be free of error; and only 13 years before Bacon wrote his *Opus majus* was the ban raised. It is therefore evident that considerable time was needed for the assimilation of the new knowledge and for a slow growing appreciation of its method.

A thousand years before Bacon, Eusebius said with regard to scientific questions: "It is not through ignorance of the things admired by them, but through contempt of their own useless labor, that we think little of these matters, turning our souls to the exercise of better things." The attitude of the church had not changed in the least, for Bacon says: "When the philosophers are told in these days that they ought to study perspective, or geometry, or the languages, they ask with a sneer: What is the use of these tings? insinuating their uselessness. They refuse to hear a word said with reference to their utility; they neglect and condemn the sciences of which they are ignorant."[6]

We can easily understand that a man of Bacon's temperament and independence had no use for Albertus Magnus who prided himself that he taught the ancient science in such a way that no one could recognize his own personal views. The animosity shown in the above quotation is a much more serious matter than a disagreement of two scholars would be at the present time. Not two men, but two schools of thought were battling with each other. Each had devised a method for the assimilation of the new knowledge, and either school used all its influence to suppress the other. Personally I am convinced that Roger Bacon would not have hesitated a moment to silence the great Albert and his adherents, had he had the power to do so. At that time a compromise was impossible; freedom of thought had not yet been discovered.

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[6] *Opus tertium,* ch. VI: "Nam philosophantes his diebus, quando dicitur eis quod sciant perspectivam, aut geometriam, aut linguas, et alia multa, quaerunt cum derisione, 'Quid valent haec?' asserentes quod inutilia sunt. Nec volunt audire sermonemde utilitate; et ideo neglegunt et contemnunt scientias quas ignorant."

If now we consider Bacon's actual accomplishments in science a little more closely we find nothing very remarkable, though we cannot help but admire his encyclopedic knowledge of details and the clear grasp of their interrelation.

In mathematics he has added nothing to knowledge, as far as we can see. No mathematical treatise which might form a part of his contemplated all-embracing work has ever been found. This is disappointing, for Roger states that the quadrature of the circle for which the ancients had searched in vain, had finally been accomplished.[7] It would have been interesting to compare his proof of this fallacy with that of Cusanus, 150 years later.

Bacon used his knowledge of astronomy to make an immense number of clever calculations, especially with a view of fixing the dates of occurrences mentioned in the Bible. Thus he proves to his perfect satisfaction that creation took place in the fall of the year,[8] and he knows the exact date when the flood began. He also calculated the size of the earth. This was a rather complicated problem. The decimal system was not in general use at that time and all the data which he had at his disposal were that the length of one degree on the earth's surface was fifty-six miles plus two-thirds of a mile plus twenty-seven ninetieths plus one six hundred and thirtieth of a mile. It needs real mathematical gymnastics to reach a solution. His final result was not very far from the truth; in fact, it was nearly as accurate as that on which 400 years later (in 1666) Newton according to tradition attempted to verify his law of gravitation with the result that he did not dare publish this fundamental law, until Picard 18 years later had made new and more accurate measurements.[9] Bacon found further that the diameter of the earth was $3\frac{2}{5}$ times the diameter of the moon, a value not bad as an approximation; but when he got farther away from mother earth he was less successful, for he found that the diameter of the sun was only 5½ times greater than that of the earth.

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[7] *Opus majus, pars* I, ch. VI: "Nam quadraturam circuli se ignorasse confitetur, quod his diebus scitur veraciter."

[8] *Opus majus,* pars IV, (*loc. cit.*): "Nam multi voluerunt secundum sententiam vulgi, quod mundus fuerit creatus circiter aequinoctium vernale; sed alii apud aequinoctium autumnale; quia in veritate secundum Hebraicum veritatem, annus, quantum ad seriem temporis naturalem, incipit circiter aequinoctium autumnale."

[9] This is merely a tradition. Newton's difficulty seems to have been of an entirely different nature. See Cajori, *History of Physics,* p. 58.

In spite of some mistakes of this sort, he was correct in many other calculations. He very earnestly and impressively urged a change of the calendar by showing clearly that Christian chronology did not agree with astronomical observations. Though he calls this error in itself *"horribilis,"* this is nothing in comparison with the fact that the whole order of ecclesiastic festivals is confounded. It seems to him inexcusable that in 1267 Lent began and ended a week too late and that therefore the infidels, Arabs, Hebrews and Greeks pointed with abhorrence at the stupidity of the Christians.[10]

Bacon was by no means the first to advocate an improvement of the calendar, though this is sometimes claimed by his admirers. He himself mentions Theophilus, Eusebius, Victorinus, Cyrillus, Beda and others who had before him labored for the same reform. Neither was Bacon successful. The necessary change was not made until more than 300 years later.

We should not blame Bacon for believing implicitly in astrology. All the best thinkers of his time did so and even his great namesake, three centuries and a half after Roger, had not abandoned it although the Copernican theory had at that time been accepted by the leading astronomers.

As we pass on to physics we find that in this science also Bacon's contributions of new facts are very meager. At his time physics consisted of the most elementary mechanics and what we call now geometrical optics. Very little was known of electricity and magnetism. While he was an admirer of Aristotle and claims to have read all his books, he was not a blind follower like Albertus Magnus. In fact he praises Robert of Lincoln for disregarding the writings of Aristotle and working out his theories independently. Besides large portions of the *Opus majus* (*"De scientia perspectiva"*) and *Opus tertium* devoted to optics his main work on this subject is *"De multiplicatione specierum."*

Roger Bacon knew the law of reflection and also that light may be refracted, though of course he was unacquainted with the law of refraction which was not discovered until 1621, by Willibrod Snell. He was much interested in the practical application of reflection by means of spherical mirrors, but did not know how to find their focus. Nevertheless he believed that by experiments in this direction much might be achieved. His friend Peter Peregrinus had already worked on such mirrors for three years and Bacon hoped that he would soon be able to perfect burning mirrors of great power. Of what enormous value would these be, he exclaimed. The armies of the Saracens and other enemies of Christendom could be burned at long distances by a dozen of such mirrors, attended to by a scientist and two helpers, and thus much bloodshed would be prevented.[11] What an elegant and inexpensive method of abolishing war and establishing universal peace!

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[10] *Opus majus,* pars IV (*loc. cit.*): "Nam omnes literati in computo et astronomi sciunt haec, et derident ignorantiam praelatorum qui haec sustinent Atque philosophi infideles, Arabes, Hebraei, et Graeci, qui habitant inter Christianos ut in Hispania et Aegypto et in partibus orientis, et in multis aliis mundi regionibus abhorrent stultitiam quam conspicuunt in ordinatione temporum quibus utuntur Christiani in suis solemnitatibus."

Bacon's knowledge has been much overestimated. Some authors thought he invented the telescope. This is impossible. He did not even know that the greatest magnifying effect of a simple lens is obtained by holding it near the eye; for like Alhazen 200 years before him, he advised that the lens be laid upon the object to be viewed through the glass.[12] The great exponent of experimental work must have copied this mechanically without making independent observations. He knew, however, that the magnifying power depends upon the angle under which an object appears and he dreamed of the time when by a combination of lenses this angle might be increased so much that we might read the smallest script at incredible distance, that a boy would appear as a giant, that a small body of soldiers would be seen as a large army. By making the images of sun, moon and stars descend upon the heads of enemies, they would flee terror-stricken.[13] To distort this sentence as meaning that Bacon actually knew a telescope or microscope, is rather daring. He merely stated a problem which he hoped might be solved by future generations.

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[11] *Opus tertium,* ch. XXXVI: "Certe si duodecim talia specula haberent Aconenses, et illi qui sunt ultra mare Christiani, ipse sine effusione sanguinis pellerent Saracenos de finibus eorum; nec oportet Dominum regem Franciae cum exercitu transire pro illa terra acquirenda. Et quando ibit, plus valeret ei habere illum magistrum cum duobus aliis, quam majorem partem exercitus sui, ne dicam totum exercitum."

[12] *Opus majus,* pars V, ("De scientia perspectiva," pars III, 2, ch. IV): "Si vero homo aspiciat literas et alias res minutas per medium crystalli vel vitri vel alterius perspicui suppositi literis, et sit portio minor spherae cujus convexitas sit versus oculum, et oculus sit in aere, longe melius videbit literas et apparebunt ei majores."

[13] *Ibid.,* ultima distinctio, ch. IV: "Nam possumus sic figurare perspicua, et taliter ea ordinare respectu nostri visus et rerum, quod frangentur radii et flectentur quorsumcunque voluerimus, ut sub quocunque angulo voluerimus videbimus rem prope vel longe. Et sic ex incredibili distantia legeremus literas minutissimas et pulveres ac arenas numeraremus propter magnitudinem anguli sub quo videremus, et maxima corpora de prope vix videremus propter parvitatem anguli sub quo videremus, nam distantia non facit ad hujusmodi visiones nisi per accidens, sed quantitas anguli. Et sic posset puer apparere gigas, et unus homo videri mons, et in quacunque quantitate—sic etiam faceremus solem et lunam et stellas descendere secundum apparentiam hic inferius, et similiter super capita inimicorum apparere et multa consimilia, ut animus mortalis ignorans veritatem non posset sustinere."

It is this almost inspired presentiment of the coming development of science, this scientific instinct, which makes Bacon so interesting to later generations. While reading his optical works I found a most unsuspected treasure, namely what I believe to be the first appearance of the undulatory theory of light, in a rather crude form, it is true, but easily recognized. It is his theory of the propagation of species. The translators speak of Bacon's theory of propagation of "force," a word whose exact meaning as a physical quantity bothers us physicists even at the present time. But his species is not a force at all, but a quantity, as flexible and unreal as *our* much admired electromagnetic vibration of the ether. It is something caused by the acting body[14]—in the case of light, by the luminous body, from which the species proceeds into space in straight lines. While there may be a resemblance to the forms or replicas which according to Lucretius and the earlier philosophers proceeded from all luminous bodies, it would be an entire misapprehension of Bacon's views to identify these forms with his species. The species is not a part of the acting body, i. e., the body which we see; but it is generated in the surrounding medium. The luminous source acts on the first portion of the medium, stimulating its latent energy to the generation of the species. This portion, thus transmuted, acts on the part of the medium next succeeding, and so the action proceeds from point to point.[15] Species has therefore no bodily existence apart from that of the medium through which it passes, and light cannot be a material body.[16] Moreover each species lasts only an imperceptible time, since the medium has a nature opposed to the creation of species and destroys it, but not until it has affected in a similar manner the surrounding medium. The luminous body must therefore cause one species after another in very rapid succession, but since they take place in time, it should be possible to count them.[17] Finally the propagation of species through space requires time, for otherwise light could be at once at the beginning of space, at its middle and at the end at the same time; which is a property of the Creator alone and not of any created thing.[18]

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[14] *Multiplicatio specierum,* pars I, ch. I: "Species autem non sumitur hic pro quanto universali apud Porphyrium, sed transumitur hoc nomen ad designandum primum effectum cujuslibet naturaliter."

[15] *Ibid.,* pars I, ch. III: "Quod non potest species exire nec emitti ab ipso agente, quia accidens non permutat subjectum, nec pars substantialis sine corruptione substantiae totius.—Sed species est effectus agentis naturalis, et naturaliter productus est, quare species ipsa debet de potentia materiae generari.—Unde forma ignis non alterat materiam vel alterius, ergo non potest species facta in prima parte patientis alterare illam partem ad alium effectum producendum in ea, sed partem secundam. Et ita quae fit in secunda alterabit tertiam, et sic ulterius."

[16] *Ibid.,* pars III, ch. I: "In primo consideratur an species sit corpus veraciter, sicut multi posuerunt. Quod vero non sit corpus probatur per hoc, quod non dividit latera continentis medii, quod est locum in alio occupare, ut omnes sciunt. Et ideo si species esset corpus secundum se, essent duo corpora simul, quod non est possibile."

How much like the more modern undulatory theory of light this is. The species are periodic disturbances impressed upon the medium which due to its "contrary disposition" opposes them, but at the same time hands on the disturbance from point to point with a great, though finite, velocity. The carrier of the disturbances is an ether endowed with such physical properties as suited Bacon's purpose and as real as any of its many successors. The existence of a vacuum was to him an impossibility.[19] To find such a theory, even in a crude form in a work written six and one-half centuries ago, seems remarkable indeed. And still more. In his search after a unified view, Bacon extends the meaning of species to include the action of gravitational and other forces. It almost appears as if he had felt instinctively that there must be such a thing as that which we now call energy.

Personally I do not believe that Bacon was a sufficiently deep thinker to have originated the above theory, mixed up, as it is, with crude generalizations which are characteristically Baconian. His works show clearly a remarkable power of adaptation to Arabian scholarship, and I hope that further study may allow me to trace the "undulatory theory" back to an earlier author.

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[17] *Ibid.*, pars VI, ch. I: "Dicto de generatione speciei et multiplicatione, nunc dicendum est de corruptione. Et patet eam esse corruptibilem, quia est generabilis.....Caeterum natura patientis specifica nata est ad contrariam speciei, si contarium habeat, vel ad dispositionem contrariam illi quae per speciem inducitur....et sic per consequens species lucis vel alterius corrumpitur per accidens per contrarium, etsi non per se."

Ibid., ch. III: "Deinde tertium consideratum est quod cum idem agens iterum redeat super eandem naturam patientis, facit impressionem seu speciem diversam numero a priore, et ideo effectus numeratur."

[18] *Opus tertium*, ch. XLII: "Iterum, nulla virtus agit in instanti; sicut probatur sexto Physicorum.....Iterum, nihil, potest simul et semel esse in diversis locis, nisi Creator. Sed si in instanti fieret tunc esset simul et semel in principio spatii, et in medio, et in fine, et per consequens in omnibus partibus spatii; ergo non esset creatura."

[19] *Opus majus*, pars V ("De scientia perspectiva," pars I, distinctio nona): "Sed si vacuum poneremus inter coelum et terram, nec esset densum nec rarum.....Atque vacuum non habet aliquan naturam, unde impediat speciem, nec unde resistat speciei, quia nulla natura est ibi....species enim est res naturalis et ideo indiget medio naturali, sed in vacuo nulla natura est."

Bacon was a man of great imagination, as every scientist ought to be. While our modern scientific dreams are checked on all sides by innumerable laws of nature which they must obey, *he* could give his fancy free rein. Listen to some of his prophecies:

"Ships will be built which, with a single man steering them, will move through rivers and the ocean with a greater speed than if they were filled with oarsmen. Carriages can be made to move with incredible speed without the help of any animals. Flying machines will be constructed so that one man sits in the middle of the apparatus, revolving some ingenious device by means of which wings beat the air after the manner of flying birds."[20]

In spite of all these speculations Bacon does not lay great emphasis upon them. In fact they are not found in his more serious work. Though he had quite a reputation as an alchemist and a magician, he holds all magic in contempt. In describing some astonishing experiment with the magnet, he says with fine humor: "Magicians make this experiment, mumbling incantations and believing that things happen by virtue of their songs. I have neglected chanting and have understood the marvelous work of nature."[21] He clearly recognized that a science, based upon superstition, speculation and arm-chair philosophy, cannot be of permanent value. But just this kind of science was taught at his time, disputations were held about the meaning of infinity, or in what language angels converse with each other, or how many angels can stand upon the point of a needle.

Bacon's fame does not rest upon any discovery he may have made, nor upon his actual knowledge of scientific facts, nor upon his more or less correct interpretation of human experiences, but upon the fact that more than any other of the early scholars he emphasized that none of the sciences could make any progress without the application of what he terms the "*scientia particularis,*" namely experimental science. "All sciences," he says, "are connected; they lend each other material aid as parts of one great whole, each doing its own work, not for itself alone, but for the other parts; as the eye guides the body and the foot sustains it and leads it from place to place."[22] "But above all these there is one, more perfect than any, which they all serve, namely experimental science. It alone can test their conclusions, which cannot be done by mere argument."[23]

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[20] *De secretis operibus artis et naturae, et de nullitate magiae,* ch. IV: "Nam instrumenta navigandi possunt fieri sine hominibus remigantibus, ut naves maximae, fluviales et marinae, ferantur unico homine regente, majori velocitate quam si plenae essent hominibus. Item currus possunt fieri ut sine animali moveantur cum impetu inaestimabili; ut aestimamus currus falcati fuisse, quibus antiquitus pugnabatur. Item possunt fieri instrumenta volandi, ut homo sedeat in medio instrumenti revolvens aliquod ingenium, per quod alae artificialiter compositae aerem verberent, ad modum avis volantis. Item instrumentum, parvum in quantitate ad elevandum et deprimendum pondera quasi infinita, quod nihil utilius est in casu."

[21] *Opus majus,* pars VI ("Scientia experimentalis," ch. XII): "Et ideo magici utuntur hoc experimento, et dicunt carmina diversa, et credunt quod ex virtute carminum istud contingat. Et ego neglexi carmina et inveni opus naturae mirabile."

"Experimental science has three great prerogatives among other sciences: First, she tests by experiment their noblest conclusions; next, she, the sole mistress of speculative sciences, discovers magnificent truth to which these sciences of themselves can by no means attain; her third dignity is, that she by her own power and without respect to other sciences investigates the secrets of nature."[24]

The examples which Bacon gives for these prerogatives are very curious and amusing. The first is a—for that time admirable—research as to the nature of the rainbow, though the moment he leaves the solid ground of experimentation he falls into error. For example, he says there can be only five colors in the rainbow, because five is a more perfect number than seven, the number which Aristotle had chosen.[25] While he experiments skilfully with reflection and refraction of light he reaches amusing conclusions: The direct ray is the most perfect, pertaining to the nature of God; then come the refracted rays corresponding to the vision of angels; while we poor mortals must be content with the weakest of them all, namely with a vision by reflected rays. For the apostle Paul says: Now we see through a mirror darkly, but then from face to face.[26]

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[22] *Opus tertium,* ch. IV: "Nam omnes scientiae sunt connexae, et mutuis se fovent auxiliis, sicut partes ejusdem totius, quarum quaelibet opus suum peragit, non solum propter se, sed pro aliis: ut oculus totum corpus dirigit, et pes totum sustentat, et de loco ad locum deducit; et sic de aliis."

[23] *Ibid.,* ch. XIII: "Sed praeter has scientias est una perfectior omnibus, cui omnes famulantur, et quae omnes miro modo certificat; et haec vocatur scientia experimentalis, quae negligit argumenta, quoniam non certificant, quantumcunque sint fortia, nisi simul adsit experientia conclusionis, ut ostendo in tractatu de ista scientia. Et ideo haec docet experiri conclusiones nobiles omnium scientiarum, quae in aliis scientiis aut probantur per argumenta, aut investigantur per experientias naturales et imperfectas."

[24] See Whewell's *History of the Inductive Sciences,* Vol. I, p. 375.

[25] *Opus majus,* pars VI, ch. XII: "Quum enim Aristoteles dicit in Sensu et Sensato septem esse colores....sed quinque principales colores sunt per naturam distincti. Nam quinarius est melior numeris omnibus, ut Aristoteles dicit in libro Secretorum....Et quia numerus quinarius res certius distinguit et melius, ut dictum est, ideo natura magis intendit quinque colores."

[26] *Opus majus,* pars V: ("De scientia perspectiva," pars III, ultima distinctio, ch. II): "Aliter vero triplicatur visio secundum quod fit recte, fracte,

The examples of the second prerogative of experimental science are three: the art of making an artificial sphere which shall move with the heavens by natural influences, i. e., a *perpetuum mobile.* This was the great invention described by Bacon's friend, Peter Peregrinus. Secondly, the art of prolonging life, which experiment may teach, though medicine has no means of securing it, except by regimen. Thirdly, the art of making gold, finer than fine gold, which goes beyond the power of alchemy.

The third prerogative of experimental science, arts independent of received sciences, is shown by curious examples, many of them whimsical traditions. Thus it is said that the character of a people may be changed by altering the air. This refers to the answer which Aristotle is said to have given Alexander who wanted to know what he should do with certain barbarous nations. The reply was: If you can alter the air, permit them to live; if not, put them to death.

Arguments like these, should not, however, prejudice us against Bacon and the real service which he has rendered science. He outlines a definite method; he points to the only way in which progress may be achieved; and it is this service which entitles him to an honored place in history. It is true that there were experimental scientists before him, Ptolemy, Alhazen and many others, but none of them has spoken so clearly of the supreme importance of experiment, as he whose fanciful speculations appear childish in the better knowledge of to-day. In his appreciation of experimental demonstrations Roger Bacon was 300 years ahead of his time; he anticipated the scientific renaissance of the sixteenth century. Indeed, I place him in this respect far above the second Bacon though the latter managed to earn greater fame. But Roger Bacon was after all a child of his time. He was an astrologer and an alchemist, and his arguments did not differ to any marked extent from those employed by the despised teachers of the university of Paris. His own knowledge and accomplishments were advertised by him as unblushingly as by other learned men of his time. He could teach in three or six months all that he himself had learned in forty years of con-

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et reflexe. Prima est perfectior aliis, et secunda certior est, tertia incertissima. ....nam rectitudo visionis Deo debetur; declinatio a rectitudine per fractionem, quae debilior est, anglicae naturae convenit: reflexiva visio, quae est debilior, homini potest assignari.....Et homo habet triplicem visionem, unam perfectam, quae erit in statu gloriae post resurrectionem; aliam in anima separata a corpore in coelo usque ad resurrectionem, quae debilior est; tertiam in hac vita, quae debilissima est, et haec est recte per reflexionem. Secundum quod dicit apostolus 'videmus nunc per speculum in aenigmate, sed in gloria a facie ad faciem.'"

tinuous study; he would even undertake to teach Hebrew or Greek in three days.[27] Though his name was not mentioned in learned treatises of later times he must have had a number of secret admirers; for what better proof could we ask for than the fact that his writings have frequently been literally copied without any credit being given to him. Scientific plagiarism does not seem to have been a crime in those times, and I believe that *Francis* Bacon practised it cheerfully and extensively after some good fortune had made him acquainted with the works of the old monk, his namesake.

Not until the last century has Roger Bacon been shown to be the real author of much wisdom attributed formerly to others. Let me close with an interesting example. All that Christopher Columbus knew of Greek and Roman authors; all references of Aristotle, Strabo, and Seneca as to the proximity of Eastern Asia to the pillars of Hercules, references, which according to Columbus's son, Don Fernando, induced his father to look for the discovery of the East Indies—all this the admiral learned from the writings of cardinal Alliacus (Peter d'Ailly). He carried them with him on his travels; he translated in a letter from Haiti, addressed to the Spanish monarch a part of Alliacus's treatise *De quantitate terrae habitabilis.* Little did he know that Alliacus in his turn, had copied this, almost word for word, from the *Opus majus* of Roger Bacon.[28]

[27] *Opus tertium,* ch. XX: "Multum laboravi in scientiis et linguis, ut posui jam quadraginta annos postquam dedici primo alphabetum; et fui semper studiosus....et tamen certus sum quod infra quartam anni, aut dimidium anni, ego docerem ore meo hominem sollicitum et confidentem, quicquid scio de potestate scientiarum et linguarum....sed certum est mihi quod infra tres dies ego quemcunque diligentem et confidentem docerem Hebraeum, ut sciret legere et intelligere quicquid sancti dicunt....Et per tres dies sciret de Graeco iterum; et non solum sciret legere et intelligere quicquid pertinet ad theologiam, sed ad philosophiam et ad linguam Latinam."

[28] Humboldt's *Kosmos,* Vol. II.

ROGER BACON, LOGICIAN AND MATHEMATICIAN.

BY PHILIP E. B. JOURDAIN.

ALTHOUGH Bacon was preeminently a physicist he was never tired of praising mathematics. Theologians, he said, ought "to abound in the power of numbering."[1] Then again, "divine mathematics alone can purge the intellect and fit the student for the acquirement of all knowledge." He showed himself much more wide-minded than his more famous namesake, Francis Bacon: for not only did he state as a fundamental principle that the study of natural science must rest on experiment, but he also explained how astronomy and the physical sciences rest ultimately on mathematics, and progress only when their fundamental principles are expressed in a mathematical form. Mathematics, he said, should be regarded as the alphabet of all philosophy.

Roger Bacon strove unsuccessfully to replace logic in the curriculum of the University of Oxford by mathematical and linguistic studies. In fact, he had a low opinion of the utility of logic, because reasoning seemed to him to be innate. We can form some idea of how far Bacon was in this case in advance of his times, when we reflect that even at the present day Oxford University still cultivates the Aristotelian logic with its errors and limitations, and its learned professors regard modern and more profound logical work with contempt, for no other apparent reason than that it is a product of the last sixty years. The fact is that Roger Bacon and all the really scientific objectors to scholastic logic, including Kant, were quite right: the Aristotelian or merely syllogistic logic of classes and propositions is quite insufficient for the purposes of even elementary arithmetic and geometry. For any scientific purpose, we must leave scholastic logic in the school. In the present problems of science we can no more effect anything with it than a regiment armed with bows and arrows could take Gibraltar. Logic has now recognized that it must, if it is to be of any real use in the world, make use of a symbolism more or less analogous to the ingeniously thought-out and economical (in Mach's sense) symbolism of algebra. Modern logicians see that using algebraical signs like "$a+b$" does not necessarily imply that "a" and "b" stand for numbers, any more than French people, when they speak of a "*chou*", mean a shoe.

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[1] This and the following quotations are taken from W. W. Rouse Ball, *A Short Account of the History of Mathematics,* 4th ed., New York and London, 1908, pp. 169, 175, 176.

II.

Let us now turn to Bacon's mathematical work. The most important part is his work on "perspective."[2] But we will here fix our attention on his discussion of "continuity." Nowadays it is the usual opinion among those who have studied the subject that it was Zeno the Eleatic who first incontrovertibly showed the untenability of the Pythagorean doctrine that lines, surfaces, and solids are composed of points. I refer more especially to the third and fourth of Zeno's famous arguments about motion, preserved—though probably in a mangled state—by Aristotle. Zeno's first two arguments about motion, which are far better known and are—unlike the others—readily refutable at the present day, may conceivably be directed against the opposite view that spaces are divisible to infinity. Aristotle was a supporter of the doctrine of infinite divisibility and an opponent of Zeno, and devoted much space in his *Physics* to the discussion of "continuity," which he expressed by the Greek word συνεχής.

Now, in the thirty-ninth chapter of his *Opus tertium*,[3] Bacon discussed continuous spatial magnitudes, and emphasized the impossibility of generating such magnitudes from single point-elements. His proof of this was as follows. If a square were formed of points—for example, suppose that a side contained 5 points and a whole square was formed out of five columns or five rows of five points each—then the diagonal would also be formed of five points. The diagonal, then, would be equal to a side, and this is geometrically impossible. Kurd Lasswitz[4] showed that this proof of Bacon's occurred previously with the Arabian mathematician

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[2] Cf. Moritz Cantor, *Vorlesungen über Geschichte der Mathematik*, Vol. II, pp. 97-99. 2d ed., Leipsic, 1900.

[3] *Opera quaedam hactenus inedita* (ed. J. S. Brewer), Vol. I, 1859, p. 132. Cf. M. Cantor, *op. cit.*, p. 97.

[4] *Geschichte der Atomistik vom Mittelalter bis Newton.* Hamburg and Leipsic, Vol. I, pp. 194, 149.

Mutakallimun. It may be remarked that Bacon, especially in his work on "perspective," made great use of the writings of Arabian authors.

The Greek language was known, as Bacon himself indicated, by many of the learned of the thirteenth century, but there was for the most part a lack of Greek works.[5] It can hardly be doubted that Bacon was not familiar with the fourth and last of Zeno's arguments about motion, which was against the composition of space out of indivisibles, especially as Aristotle in his *Physics* had in all probability mangled this argument out of all similarity to its original form. And indeed, outwardly, Zeno's argument is very different from that of Bacon. But both have this in common: They can only be satisfactorily answered by one who knows that the modern theory of infinity and continuity has resolved all the contradictions that were formerly thought to subsist in these notions. In Bacon's case, we now know that the diagonal of a square may, in Georg Cantor's terminology, contain the same cardinal number of points as the side, although they are of different lengths. It is not, then, impossible to hold that a continuous line is composed of points. Both Zeno and Bacon seem to have proved that we cannot do this if the points are finite in number.

Finally, it may be remarked that Aristotle's conception seems to have made its first explicit appearance in the West in a definition[6] of Thomas Bradwardine, who was probably born a few years before Roger Bacon died.

[5] Cantor, *op, cit.,* p. 99.

[6] *Ibid.,* p. 119.

MISCELLANEOUS.

BOOK REVIEWS AND NOTES.

THE NATURE OF MATHEMATICS. By *Philip E. B. Jourdain, M.A.* "The People's Books," London and Edinburgh: T. C. and E. C. Jack; New York: Dodge Publishing Co. 92 pages.

This is a volume of an extraordinarily inexpensive series of books on science, philosophy, religion, history, economics, and literature published in Great Britain at sixpence each. "The purpose of this little volume," says the the author (p. 7), "is not to give—like a text-book—a collection of mathematical methods and examples, but to do, firstly, what text-books do not do: to show how and why these methods grew up. All these methods are simply means, contrived with the conscious or unconscious end of economy of thought-labor, for the convenient handling of long and complicated chains of reasoning. This reasoning, when applied to foretell natural events, on the basis of the application of mathematics, as sketched in the fourth chapter, often gives striking results. But the methods, of mathematics, though often suggested by natural events, are purely logical....In this book I shall not pay very much attention to the details of the elementary arithmetic, geometry, and algebra of the many text-books, but shall be concerned with the discussion of those conceptions—such as that of negative number—which are used and not sufficiently discussed in these books. Then, too, I shall give a somewhat full account of the development of analytical methods and certain examinations of principles."

The first five chapters are devoted to a historical exposition of the growth of mathematical methods: The growth of mathematical science in ancient times; the rise and progress of modern mathematics—algebra; the rise and progress of modern mathematics—analytical geometry and the method of indivisibles; the beginnings of the application of mathematics to natural science—the science of dynamics; the rise of modern mathematics—the infinitesimal calculus. After a chapter on modern views of limits and numbers, modern conclusions as to the nature of mathematics are dealt with in the final chapter. "In the historical part," says the author on page 8, "we shall see that the actual reasonings made by mathematicians in building up their methods have often not been in accordance with logical rules. How, then, can we say that the reasonings of mathematics are logical in their nature? The answer is that the one word 'mathematics' is habitually used in two senses, and so, as explained in the last chapter, I have distinguished 'mathematics,' the methods used to discover certain truths, and 'Mathematics' the truths discovered. When we have passed through the stage of finding out, by external evidence or conjecture, how mathematics grew up with problems suggested by natural events, like the falling of a stone, and then how something very abstract and intangible but very real separated out of these problems, we can turn our attention to the problem of Mathematics without troubling ourselves any more as to how, historically, it gradually appeared to us quite clearly that there is such a thing at all as Mathematics—something which exists apart from its application to natural science. History has an immense value in being suggestive to the investigator, but it is, logically speaking, irrelevant. Suppose that you are a mathematician; what you eat will have an important influence on your discoveries, but you would at once see how absurd it would be to make, say, the momentous discovery that 2 added to 3 makes 5 depend on an orgy of mutton cutlets or bread and jam. The methods of work and daily life of mathematicians, the connecting threads of suggestion that run through their work, and the influence on their work of the allied work of others, all interest the investigator because these things give him examples of research and suggest new ideas to him; but these reasons are psychological and not logical." In this is shown the second object of the book.

The principal points of the book are: (1) A discussion of the question as to the "use" of mathematics; (2) The emphasis on the fact that mathematics is a living science; depends, psychologically speaking, on the natural sciences; proceeds, like them, by means of economizing thought (pp. 6, 11, 12, 16, 18, 20, 28, 33, 53, 69, 71 75, 89 and what may be called *faith* (pp. 32, 34, 43, 52); (3) That the essential character of mathematics is that it deals with the notion of *any* (pp. 15, 33, 48, 69, 85, 86); (4) The nature of mathematics is *logical,* so that "all those petty questions—sometimes amusing and often tedious—of history, persons, and nations are irrelevant to Mathematics in itself" (p. 9); (5) Analytical geometry is regarded as a *picture* of algebraical processes; (6) The explanation of the infinitesimal calculus.

It may be mentioned that a part of the views here given is taken from an article in *The Monist* for 1908. *ϕ*

August 1914

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